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Research Article

On the Added Value Conception for the Implementation Instruments Towards Sustainability of the Markets with Carbon Risk

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Abstract

The key component in achieving the efficient carbon management, which involves mitigating the vast majority of carbon dioxide emissions in balance with carbon dioxide utilization technologies, is market sustainability implementation. At the same time, a value-added model is used, which forms the basis for determining carbon risk.

We`ve undertaken the multi criteria modelling for analytical approximation of product life cycle, based at the wide area of parameters for control and optimization, in particular: (1) the quantitative assessments for the balance existence at the market of product with carbon risk; (2) the quantitative scheme for carbon risk sensitivity analysis; (3) the conditions for production and consumption participants being the motivation to promote sustainability; (4) the relationship between waste utilization costs and technology efficiency being the motivation for carbon dioxide emissions minimization; (5) the innovative stock-exchange under the sustainability criteria.

The practical prospects for the sustainability management of the product with carbon risk, including the energy markets, are seen via the vector optimization technique, while the represented quantitative indicators are well providing market participants with strong base for decision making along the environmental management.

The proposed model approach (carbon risk, managed market, innovative stock-exchange) provides the novelties for environmental management under the sustainability criteria.

Keywords

sustainability management; market engineering design; carbon risk; sensitivity analysis; waste utilization costs

Highlights:

- The quantitative assessments for the balance existence at the market of product with carbon risk
- The quantitative scheme for carbon risk sensitivity analysis
- The conditions for production and consumption participants being the motivation to promote sustainability
- The relationship between waste utilization costs and technology efficiency being the motivation for carbon emissions minimization
- The functional diagram of the innovative stock-exchange practicing under the sustainability criteria

1. Introduction

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the principal conclusions. As far as possible, please keep the introduction comprehensible to scientists outside your particular field of research. The urgency of the problem of climate protection has brought energy and Green House Gas (GHG) emissions markets to the top of the Agenda 21. The basis of the new agenda is the creation and development of energy markets. An important component is the development of a set of models that would facilitate the adaptation of market mechanisms towards a low-carbon economy. These models are aimed for reducing greenhouse gas emissions. These measures will make it possible to approve a system of economic development based at low energy consumption. At the same time, market mechanisms are considered today in the broader context of energy system management, which requires the development of theory and practice of market engineering design. So, there is need to look at the relevant implementation tools based on Life Cycle Assessment (LCA) and Market Engineering Design (MED), which relate to products with Carbon Risk (CR) [1, 2]. Also, currently the International Organization for Standardization (ISO), which coordinates standardization issues in the field of organizational management, production and technology, is planning to publish the first international standard for “net zero” in 2025. The standard will be based on the ISO guidelines agreed in 2022 during COP27 [3]. These guidelines contain the main recommendations for inclusion in the draft standard, reviewed as comprehensive study of greenhouse gas emissions in order to develop ways to reduce them; consideration of appropriate localized emissions, taking into account their usefulness at the local level; the priority of the state in which the removal exceeds greenhouse gas emissions; development of low-waste and closed-loop technologies; the priority of making decisions, based on reliable knowledge and management experience. From the perspective of the concept of sustainable development, the decision to turn the guidelines into a full-fledged "net zero" standard was driven by the need to involve more participants at the international and local levels in setting reliable targets for reducing greenhouse gas emissions that can be confirmed in practice. It has been recognized that ISO standards give the guidance and support. And already ISO governs a lot standards related to energy, circularity and environmental management. So, ISO’s work needs to be happening in parallel with the scientific prospective research, based at the modeling well supported with market engineering design [4].

The new energy agenda undertakes the utilization of carbon dioxide, which is divided into three main areas: carbonation of minerals for the production of building materials, chemical conversion for the production of chemicals and fuels, and biological conversion for the production of chemicals and fuels. In adds, there is known design for carbon footprint reduction in energy sector with higher penetration of renewable energy resources. Large-scale minimization of carbon dioxide emissions requires fundamental breakthroughs in the development of technological processes, and the creation of an economic system that promotes the practical implementation of the new agenda [5, 6, 7].

Solving these new tasks requires the involvement of interdisciplinary knowledge. In this regard, LCA is a generally accepted approach for qualitative and quantitative modeling of complex economic processes related to greenhouse gas emissions [8]. The stages of the LCA should be carried out taking into account economic, social and environmental factors that form a systematic view on the sustainability for practical implementation of the new agenda [9, 10]. Thus, the LCA system boundary determines which elements of the product life cycle are considered in this analysis. The boundaries of the system can cover both the energy generation facility and the processes of carbon dioxide release in conjunction with the production of the target product. This approach will allow us to take into account how CO_2 emissions and other factors change in general, depending on which technology is associated to the product market with carbon risk. These models can be used as the basis for cost calculations that affect the goals and tools of technology improvement. GHG utilization is a relatively new technological challenge and is still in the early stages of implementation. Thus, the development of prototypes of both technologies and methods of their quantitative assessment for implementation in commercial markets is an urgent task. At the same time, LCA will help to optimize the sustainability performance of promising energy systems at an early stage of technological development. Such studies will make it possible to identify the key tasks necessary for the utilization of carbon on a commercial scale [10, 11]. In turn, task class, the representative of which is the theme under discussion, has developed the concept and methods for assessing the sustainability of the product life cycle. This involves an assessment of sustainability of the product life cycle – the resource stage, the production stage, the use stage and the disposal stage. The functional structure of this concept is recognized as a system-level approach, achieving progress among the activities contributes to improving their well-being, environmental safety and economic efficiency [12].

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The use of market instruments will contribute to the efficient allocation of resources in many areas of the functioning of promising energy systems [13]. In this regard, MED models and methods play an important role in ensuring energy security and the transition to a more sustainable energy supply of economic systems for the new agenda. Engineering design and market engineering are closely related concepts. Today, market design is considered as an object or as an activity. Market design is a tool for creating an effective market. Our interpretation of MED combines the design and organization of economic facilities, where the supply and demand of economic products (goods, services, technologies) is realized and can be bought and sold [14].

The complexity of the energy sector and its high importance for a competitive economy require the use of models and practical calculation schemes that can provide an adequate picture of the new economic systems being created [15]. A set of such tools is useful engineering software for the analysis and design of promising market systems [16, 17]. Thus, applied market models form the basis of engineering design for evaluation conclusions in solving complex organizational and technological problems. Thus, one of the key theoretical tasks in market modeling is the optimal mechanism for allocating resources for existing commercial activities [18, 19].

A growing number of companies define inclusion in Dow Jones Sustainability Indices as a corporate goal. These companies publicly endorse their approach to addressing companies' sustainable and proactive key long-term opportunities. And, of course, such kind practices ultimately make them more attractive to investors. This activity creates vibrant competition among companies for index membership. Each year, over 3,000 publicly traded companies, including about 800 companies in emerging markets, are invited to participate in the Corporate Sustainability Assessment. Given the potential of exchanges in contributing to economic development, it is important to not only improve the understanding of the role of exchanges and how they operate, but to work towards the creation of environments that ensure the development of well-functioning exchanges towards sustainability conception [20]. Based at the above noted, the "innovative stock-exchange process" is considered here as an iterative approximation with distributed calculations towards equilibrium at the market, taking into account the sustainability criteria.

Currently, much attention is being paid to the problem of GHG emission reduction in the developing countries. It is highly likely that research and development cooperation promotes the integration and use of external knowledge and technology, promotes research cooperation and information exchange, and implements regional collaborative innovation and development. At the same time, technological innovations can encourage enterprises to abandon backward processes, use energy-saving technologies, form an environmentally friendly production chain and reduce the intensity of carbon emissions. However, most of the literature on carbon dioxide emissions is devoted to one individual country. And existing research in developing countries on the relationship between economics, science and technology and carbon dioxide emissions is uncertain. Therefore, the choice of technological innovation and economic growth as the main variables of the study has important theoretical and practical significance [21].

Our research provides engineering tools to achieve a practical discussion of market goals that complement the traditional results of economic theory. In particular, the subject of discussion is complex products (target product and associated carbon dioxide emissions) that will be sold at the markets of products with carbon risk. Among the research tasks related to the noted topic, simplicity can be noted as a necessary condition for engineering design. Another aspect of simplicity is the mass availability of engineering tools. Thus, our efforts are aimed at developing a market design that easily fits into the existing sustainability concept and can be implemented using the existing infrastructure. The developed market design tools would be a holistic overview of the requirements for functional market design and serve as a practical guide for market participants. In addition, these tools can serve as a starting point for structuring different points of view, needs, and practical approaches. In this regard, the relevant user groups are a wide range of market stakeholders.

2. Materials and methods

The state of scientific developments, despite their multiplicity, on the issues of sustainable development has not yet become a scientific theory in the strict sense of the word for a number of reasons. Firstly, the theoretical part of the discussed area of scientific research is still poorly developed and so far it is hardly possible to talk about a sufficiently perfect and systemically holistic theory as a form of organization of scientific knowledge. Secondly, and this is the main thing, so far it is impossible to talk about the full reliability and confirmation by practice of already existing theoretical constructions, although some attempts at their mathematical formalization take place. The development of analytical tools for the purpose of establishing and researching indicators of the quality of functioning of market entities lies in this series. The existing economic practice is mainly aimed at analyzing the behavior of markets, and the tasks of market design and management, due to their extreme complexity, remain little explored. Such tasks involve an analytical consideration of the characteristics of a particular market that are adequate for the purposes of the study. The analysis of the equations of the product chain indicates the following

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statements [22]:
(I) There is an "economic" equivalent of the multi-criteria optimization problem according to the criteria W (wellbeing), S (safety), E (efficiency) based on the introduction of "total" cost functions (S) and utility functions (D). This circumstance determines the applicability of the "standard" economic tools ("costs and consumption") in order to plan and analyze the activities of the resource transformation chain to solve the problems of product life cycle sustainability management;
(II) Consideration of environmental and social risks naturally affects the conditions for the existence of competitive equilibrium in the resource transformation of the product life cycle. So, under the conditions of W, S, E-criteria, the permissible set of resource transformation becomes more "narrow" and more "short". At the same time, the indicator of the sustainability quality as a degree (in another interpretation - probability) compliance of the product's resource cycle with the established and anticipated needs will decrease with increasing marginal risks.
The applicability of these developments to the tasks of market management is largely determined by the practical implementation of the conditions of existence, uniqueness and continuous dependence of market processes on the parameters available for management. The formation of appropriate conditions and their practical interpretation remain the subject of research at the present time. In this regard, analytical models and methods are further considered, which to a certain extent are inferior to the generality of well-known classical approaches, but allow us to offer effective tools convenient for the tasks of quality management of product lifecycle sustainability.
The analysis of the life cycle of a product with carbon risk allows us to introduce three types of objects [23, 24]:
(S) Production, characterized by the difference in income and costs of the manufacturer, QSi, $1 \leq i \leq I$;
(D) Consumption, characterized by the difference between the utility of the product and the cost of purchasing it, QDj; $1 \leq i \leq J$;
(C) Carbon pollution, characterized by the volume of carbon dioxide produced, CRi, $1 \leq i \leq I$.
The chosen models allow us to operate with a generalized indicator of economic efficiency, which includes total costs, and a specific indicator of environmental safety (Carbon Risk), which is based on a model of specific greenhouse gas emissions, having of U-inverse type Kuznets curve [24]. At the same time, a value-added model is used, which forms the basis for determining carbon risk in accordance with task No. 9.4 “A system of global indicators for sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development” [25]. In this approach, indicator No. 9.4.1 "CO_2 emissions on a unit of added value, γ" is applied.

The task of market design is considered with respect to the introduced objects:
$\{QS_i \rightarrow \max\}$ & $\{QD_j \rightarrow \max\}$ & $\{CR_i \rightarrow \min\}$
This is a multi-criteria optimization problem, which is solved by maximizing the functional “L”:

$$L = \sum_I wi * qi * QSi + \sum_J wj * qj * QDj - \sum_I ni * gi * CRi$$

Here: qi, qj, gi are the normalizing constants of the corresponding dimension, and:

$$1 = \sum_I wi + \sum_J wj + \sum_I ni$$

Further, carbon pollution is proportional to value added:

$$CR = (1 - \lambda) * \gamma * AV$$

Here: AV is the Added Value, λ is the proportion of carbon dioxide produced, which is disposed of at a price φ per ton, ϒ is the technology index. The producer's income has the following distribution:

$$\pi * u = T * (1 + b) + P + c * P + d * AV + \varphi * \lambda * \gamma * AV$$

Here: T= a*K + A + M, AV = T(1+b) + P – M, K – fixed assets, A – labor costs, M – materials costs, a – depreciation rate, b – overhead rate, c – income tax rate, d – value added tax rate. The solution to the optimization problem under consideration is the supply of “ui” and the demand of “vj” according to the condition (production function of Cobb-Douglas type is used with Z1 – normalized outcome; K – capital; E – energy, A – labor; ρw and ρ- utilization and resource prices; θ, η, ϑ - inverse elasticity):

$$ui: \partial Ai(1 + b)(1 + si) + \partial Mwi + \partial Mi(1 + b(1 + si)) \quad (1)$$
$$vj: \pi = \partial Dj$$
$$\pi: \sum_I ui = \sum_J vj$$

And:

$$Ai = A1i * ui^{\theta}, A1i = Ei^{-\frac{\theta}{\vartheta}} Ki^{-\frac{\theta}{\eta}} Zi1^{-\theta},$$
$$Mwi = pwi * ui, Mi = \rho i * ui, Dj = \sigma j * Ln(1 + \frac{vj}{\varpi j})$$
$$si = d + \varphi i * \lambda i * \gamma i + +(1 - \lambda i) * \gamma i * \nu i / (1 - \frac{(1 - \lambda i) * \gamma i * \nu i}{1 + d + c + \varphi i * \lambda i * \gamma i})$$
$$\nu i = (ni * gi)/(wi * qi)$$

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Now, market design is the task of optimal selection for the production factors {θ, η, ϑ, Z1, K, E, ρ, ρw, λ, φ}, demand factors {ω, σ, ν} and tariffs {a, b, c, d}.

3. Results

3.1. Equilibrium existence

At first, there are the conditions for the equilibrium existence, that ones are introduced at the proposition when production factors are only different of every producer, K = var, E = var, and Z1 = var. Following by the equation (1) we have:

$$\mathrm{ui} = [\frac{(\pi - \rho_{\varpi} - \rho(1+b(1+s)))}{\theta(1+b)(1+s)}]^{1/(\theta-1)} A1i^{-1/(\theta-1)}$$

Based at ui, we can find:

$$\sum_I ui = I * [\frac{(\pi - \rho w - \rho(1+b(1+s)))}{\theta(1+b)(1+s)}]^{1/(\theta-1)} A1^{-1/(\theta-1)}$$

Here is used A1:

$$A1^{-\frac{1}{\theta-1}} = (\frac{1}{I})\sum_I A1i^{-1/(1-\theta)}$$

At the other hand:

$$(\frac{1}{I})\sum_J vj = \left(\frac{1}{\pi}\right)\sigma - \varpi$$

And:

$$\sigma = (\frac{1}{I})\sum_J \sigma j, \qquad \varpi = (\frac{1}{I})\sum_J \varpi j$$

So, for the equilibrium point (Z, and Z_{max} if s = d) we have:

$$A1 * \theta * (1+b) * (1+s) * Z^{\theta-1} + \rho w + \rho * \left(1 + b * (1+s)\right) = \sigma/(\varpi + Z) \quad (2)$$

The existence follows if, e.g., for θ > 1:

$$\rho w + \rho * \left(1 + b * (1+s)\right) < \sigma/\varpi \qquad (3)$$

It is seen the condition (3) turns true while ρ ↓ and s ↓ .

3.2. Carbon risk sensitivity analysis for market engineering design

In view of MED promotion it could be proposed the scheme, as it is introduced below. Let we have the following parameter set Δ={θ, η, ζ, Z1, K, E, ρ, ρw, λ, φ, ν} that one is divided into Δ1={A1, θ, ρ, ρw} and Δ2={λ, φ, ν}.

So, due the equation (2), we can find the relation Z=Z(ϒ, Δ1, Δ2) with $\partial_{\Upsilon} Z < 0$, and $\partial^2_{\Upsilon} Z < 0$ and $\partial_{\Delta 1} Z < 0$ (i.e, A1↑→Z↓, θ↑→Z↓, ρ↑→Z↓, ρw↑→Z↓), refer Figure 1:

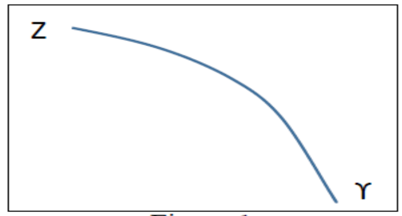

Figure 1
Production in view of technology index

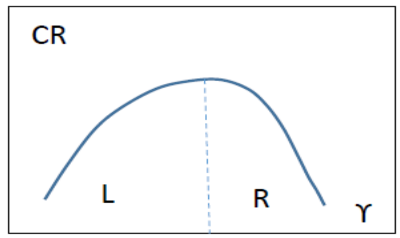

Figure 2
Carbon Risk in view of technology index

As to parameter set Δ2, we`ll take insight on it at the next part. In turn, here one can note the connection for Δ1:

$$\frac{dCR}{d\Delta 1} = \partial_{\Delta 1} CR + \partial_Z CR * \partial_{\Delta 1} Z$$

Also, we have:

$$\partial_{A1} CR > 0, \partial_Z CR < 0(*) \text{ and so } \frac{dCR}{dA1} > 0$$

(*) – at the left side of the Kuznets Curve for CR, refer Figure 2. Now, we can see that if the production side is looking for implementation CR↓, there is need for A1↓. At the same way, one can find CR↓ if θ↑ at the right side of CR (i.e., at the initial production stage). Also, at the initial production stage we have CR↓ if ρ↑ and CR↓ if ρw↑ (e.g., this can be read as the production quality is increased due to more thorough utilization of waste and choosing better resources).

3.3. Motivation to promote carbon action plan

It is known that the quality of production objects is realized by the U-inverse curve. So, in practice, it is not a fact that:

$$max_{[0,Zmax]} QS(Z) = QS(Zmax) \quad (4)$$

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At the other case, indeed, there is no reason for producer to overcome max{QS}, going to minimize CR, having the U-inverse type. It is seen, if $\partial_Z QS(Z = Zmax) > 0$, then the relation (4) is true. It was found the sufficient condition for the noted motivation:

$$Z_{max} < Z_C$$

And:

$$Z_C = [\frac{\sigma * \varpi}{\rho + \rho\omega - \rho * b * (\theta - 1) * (1 + d)}]^{0,5} - \varpi$$

The possibility to increase Z_C by parameter ρ is relatively weak, because Z_{max} has the similar functionality. So, there is need for demand factors selection to promote the motivation at carbon action plan.

3.4. Motivation for green house gas utilization

As it is known, in the long term, effective management of the market for high-risk products is associated with the possibility of partial minimization of carbon dioxide ($0 \leq \lambda \leq 1$). Thus, the following pattern has been established: with an increase in the share of minimization (λ), both CR and QS decrease. In this case, there is a difference between two cases:
(a) $\nu > \varphi$. The case takes the diseases of utilization costs seriously;
(b) $\nu < \varphi$. The case relates to high utilization costs.
Consider the dependence of the additional tariff ($F = s - d$) of the value added tax on the technological parameter $F = F(\Upsilon)$, case (a) (Figure 3).

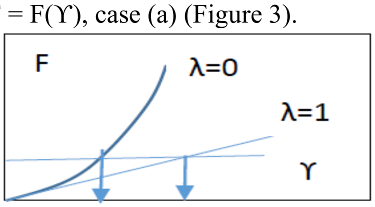

Figure 3
Additional tariff
(the case takes the diseases of utilization costs seriously)

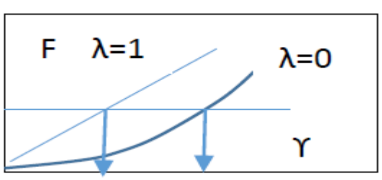

Figure 4
Additional tariff
(the case relates to high utilization costs)

If the additional tariff limit is fixed (corresponds to a constant value of the produced product), the technological parameter will increase with an increase in the share of minimization (Figure 3): $\lambda\uparrow \rightarrow \Upsilon\uparrow$. Thus, with the increase in the share of CO_2 minimization, the requirements for the quality of technology in terms of emission generation is decreased.
Case (b), (Figure 4). In this case, with an increase in the share of minimization, the technological parameter will decrease: $\lambda\uparrow \rightarrow \Upsilon\downarrow$. Thus, with the increase in the share of GHG minimization, the requirements for the quality of technology in terms of emission generation are increasing.

3.5. Innovative stock-exchange with criteria of social well-being and environmental safety

In rational exchange systems when structuring a task, it is fundamentally necessary to remove part of the calculations related to socio-ecological aspects from the sphere of possible speculation, since they are conditioned by public interests and limit the possibilities of private benefit. Thus, in the exchange process under our consideration, two goals are pursued: (A) exclusion of control by market participants over the calculation of socio-environmental indicators and (B) minimization of the consequences of speculative behavior of market participants.
The noted above problem "B" (minimizing the consequences of speculative behavior of market participants) is considered in the following context: let S and D set the "true" cost and utility functions at which true equilibrium$\{\pi_o, Z_o\}$ is achieved. In practice, uncertainty information or a speculative substitution of $S \rightarrow S + \Delta S$ can be implemented, where ΔS is a disturbance (including speculation), and similarly for demand. Then a new equilibrium $\{\pi_o(\Delta), Z_o(\Delta)\}$ is realized and, if it provides a positive economic effect, then the parties will not be interested in trading with true costs and utilities, which is the essence of the fundamental "negative result" about the impossibility of implementing a market procedure that establishes the true equilibrium. However, taking into account risk functions allows minimizing the impact of speculation by the first order of disturbances. The object of the study is the indicators of changes in economic efficiency ΔQ. If the perturbations have the order ΔS, ΔD ~ O(ε), then minimization of the value $|\partial_\varepsilon \Delta Q|_{\varepsilon=0}$ is achievable, and this ensures minimization of the impact of market uncertainties by the first order of disturbances. At the case of our discussion there are existing {wi, wj, ni} such that we have:

$$\partial_\varepsilon \Delta Q|_{\varepsilon=0} = 0$$

And so, there is no motivation of participants at market with carbon risk for speculations at least by the first order of disturbances. The other option is about the similar result, when there is information uncertainty at the

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market.
The noted above problem "A" (exclusion of control by market participants over the calculation of socio-environmental indicators in the exchange process) it can be solved both jointly with task (B) and independently. The corresponding procedure is based on a model for price dynamics in which, due to the properties of the cost and utility functions under WSE-sustainability conditions, there is a unique and stable equilibrium. Then the hybrid iterative exchange process contains two circuits of calculations. The "outer" contour provides an approximation for the price vector. The "internal" contour controls socio-economic criteria and makes an approximation for the vector of resource exchange, using feedback from the supply and demand sides. For practice, a special case of the exchange trading model presented above is also interesting – an "auction", when the supply side is represented by a fixed level of a product, for the purchase of which a limited number of competent buyers compete in terms of W,S,E-criteria.
The solution of the problems “A, B” is based on the analysis of the dynamics of resource exchange and the corresponding prices in the product chain. In this regard exchanges perform a large number of important functions that contribute to the intensification of the circulation of global capital and international economic integration. The current level of development of market relations shows that exchanges and exchange trading instruments have firmly entered the economy as one of the key mechanisms for making trade transactions, without which it is impossible to maintain the growing dynamics of the development of the economic sphere. Modern economic conditions are characterized by the growing need of commercial enterprises for specialists in the field of retail trade who are able to organize the integration of production and sales processes into exchange structures at a high level. In difficult economic conditions, bringing goods to market is not just a competitive advantage, but also the means of maintaining market positions. Based on the above noted features of the managed market, we have undertaken examination of the algorithmic approach to discuss the innovative stock-exchange.
Equilibrium existence and rational motivations conditions allow us to test the convergent process for W&S&E-sustainable participants of the each stage at the regional product life cycle chain (resources, production, consumption, waste). Let π, s^i, d^j – basic price, supply, and demand; $\Pi(k)$, $s^i(k, n)$, $d^j(k, n)$ - current price, supply, demand; for $\Pi \approx \pi$ and $1 \le i \le I$, $1 \le j \le J$, $0 \le k \le K-1$, $0 \le n \le N-1$ the principle scheme will be:

$$\Pi(k+1) = \Pi(k) + \Gamma\left(\sum_j d^j(k,N) - \sum_i s^i(k,N)\right),$$
$$\Gamma > 0$$
$$s^i(k,n+1): S^i(n+1) = \Pi S^i(k,n)$$
$$d^j(k,n+1): D^j(n+1) = \Pi D^j(k,n)$$
$$\Pi S^i(k,n) = \Pi(k) - S\Pi^i \partial RS^i\left(s^i(k,n)\right)$$
$$S\Pi^i = 1 + (\Omega S^i(s^i), \sigma(\Pi(k))$$
$$\Pi D^j(k,n) = \Pi(k) + D\Pi^j \partial RD^j\left(d^j(k,n)\right)$$
$$D\Pi^j = 1 - (\Omega D^j(d^j), \sigma(\Pi(k))$$
$$S^i(n+1) = \partial[S^i(s^i(k,n+1) + \Delta S^i(s^i(k,n+1)]$$
$$D^j(n+1) = \partial[D^j(d^j(k,n+1) - \Delta D^j(d^j(k,n+1)]$$

Here is used: RΘ(V) – risk functions for stages of product chain, Θ= S or D:

$$\Omega\Theta(V) = \frac{V}{R\Theta(V)}$$
$$\sigma(\Pi) = \Pi - \pi$$

The noted algorithm is represented at Figure 5.

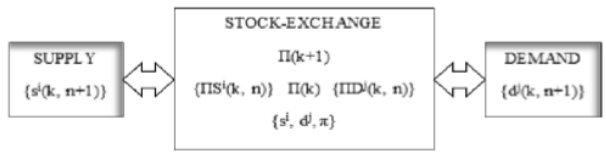

Figure 5
Innovative stock-exchange
under sustainability criteria

In the case of (SΠi = const, DΠj = const), the exchange process determines the balance of supply and demand, taking into account the criteria of social well-being and environmental safety. In the case of (SΠi = var, DΠj = var), the exchange process additionally implements a mechanism to minimize the impact of market uncertainties in the first order of disturbances.

4. Discussion

As it was mentioned above, the issue of greenhouse gas emissions is a fundamentally important component of the concept of sustainable development. The modeling of which assumes the establishment of a balance between three components of sustainability: economic efficiency, environmental safety and social well-being. The practical prospects for the sustainability management are seen via the vector optimization technique with economic, environmental, and social goals.
Sustainable development claims to evaluate the effects of different sources of uncertainty at the markets. There is well known that main assumptions on the market economy provide stimulus to disturb the basic equilibrium, e.g., at the form of the bargain speculation. So, the stability problem of sustainable development has been tested by the sensitivity conditions of the market criteria to the disturbances, including the stochastic ones. We consider the corresponding analytical formalization of this concept

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on the basis of the multi-criteria optimization toolkit.

The undertaken model approach (carbon risk and its minimization assessment, managed market, innovative stock-exchange), based on the life cycle thinking, is prospective to provide the analysis for sustainable development in the form of the stable mode along the equilibrium dynamics. At a whole, there are three groups of criteria, namely: economic efficiency (maximizing profit), environmental safety (minimizing environmental risks), social well-being (minimizing social risks) of the simulated economic activity. The above noted approach has provided us with structure and algorithm for innovative stock-exchange, operating with the vector criteria. The last one could be well suited at the international scene, being the prospective instrument towards sustainability for developing countries.

The chosen models allow us to operate with a generalized indicator of economic efficiency, which includes total costs, and a specific indicator of environmental safety (carbon risk), which is based on a model of specific greenhouse gas emissions. At the same time, a value-added model is used, which forms the basis for determining carbon risk. Technological innovations and a variety of social values constitute an additional set of tasks, which have required active and detailed engineering design of markets with carbon risk. At the same time, the multi-criteria modeling is able to provide several practical solutions, taking into account possible contradictions at the market.

5. Conclusions

It is quite natural that our work has its limitations. The considered set of market criteria is not exhaustive and is clearly adapted to the electricity market well allocated to the chosen one region. On the other hand, developers can extend our modeling to other details and cases of market design. Also, our models are limited in terms of measuring the proposed indicators. Thus, other developments may be aimed at establishing reliable quantitative indicators. We have also only outlined a tool for taking into account the relative importance of the introduced indicators. Further research will be able to adapt our main results to a number of other markets, regions and conditions. In particular, with regard to such a problem of the market economy as taking into account information uncertainty and vector criteria in the context of sustainable development strategy.

List of abbreviations

AV - Added Value
COP - Climate Change Conference (Conference of the Parties)
CR - Carbon Risk
GHG – Green House Gas
ISO - International Organization for Standardization
LCA - Life Cycle Assessment
MED - Market Engineering Design

Author Contributions

The sole author conceived and designed the study, conducted the literature review, performed the data collection and analysis, prepared the visualizations, interpreted the results, and wrote the manuscript. The author has read and approved the final version of the manuscript and is accountable for all aspects of the work.

Availability of Data and Materials

Data supporting the results of the current study are available within the article.

Conflicts of Interest

There is no Conflict of Interest.

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References

1. Guan, F.R. Insights from Behavioral Economics to Decrease Pollution and Reduce Energy Consumption. Low Carbon Economy, 10, 11-30. https://doi.org/10.4236/lce.2019.102002 Low Carbon Economy, 2019, 10, 11-30 http://www.scirp.org/journal/lce
2. Elegbede, O., Emily, O., Jolaosho, T., R Matti-Sanni, R., O Wuraola, O. Life Cycle Sustainability Assessment, In book: Encyclopedia of Sustainable Management (pp.1-11) DOI:10.1007/978-3-030-02006-4_289-1
3. The 27th UN Climate Change Conference (Conference of the Parties) 2022, https://news.un.org/en/events/cop27

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4. National Academies of Sciences, Engineering, and Medicine, 2024 Carbon Utilization Infrastructure, Markets, and Research and Development: A Final Report. Washington, DC: The National Academies Press. https://doi.org/10.17226/27732.
5. Feng D., Yifei H., Bolin Y. Peak Carbon Emissions in China: Status, Key Factors and Countermeasures. A Literature Review. Sustainability 2018, 10, 2895; doi:10.3390/su10082895 www.mdpi.com/journal/sustainability
6. National Academies of Sciences, Engineering, and Medicine, 2019. Gaseous Carbon Waste Streams Utilization: Status and Research Needs. Washington, DC: The National Academies Press. https://doi.org/10.17226/25232.
7. Wang, Y., Guo, C., Chen, X., Jia, L., Guo, X., Chen, R., et. al. Carbon peak and carbon neutrality in China: goals, implementation path and prospects. China geology, 2021, 720-746. https://doi.org/10.31035/cg2021083
8. Wanjing, C. D. Research on the composite index of the modern chinese energy system. Sustainability, 2019, doi:10.3390/su11010150 www.mdpi.com/journal/sustainability.
9. Traverso, M. Life Cycle Sustainability Assessment - A Survey Based Potential Future Development for Implementation and Interpretation. Sustainability, 2021. https://doi.org/10.3390/su132413688
10. NASEM, 2023 National Academies of Sciences, Engineering, and Medicine. Carbon Dioxide Utilization Markets and Infrastructure: Status and Opportunities: A First Report. 2023. Washington, DC: The National Academies Press. https://doi.org/10.17226/26703.
11. Korevaar, G., Tsalidis, G., Kanat, N., Tsalidis, G., Kanat, N., Harris, S. Report on the life cycle sustainability assessment, 2021. p. 21, Retrieved from https://zerobrine.eu/wp-content/uploads/2021/12/D7.6-Report-on-the-life-cycle-sustainability-assessment-LCSA-results.pdf
12. Watróbski, J., Jankowski, J., Ziemba, P., Karczmarczyk, A., Magdalena Zioło, M. Generalized framework for multi-criteria method selection. 2019. Omega 86 107–124 – [2024-03] https://doi.org/10.1016/j.omega.2018.07.004
13. Gimpel H., (eds.) Market Engineering, 2021. https://doi.org/10.1007/978-3-030-66661-3_14
14. Sim, J., Kim, B. Commitment to Environmental and Climate Change Sustainability under Competition Sustainability, 2019. 11, 2089; doi:10.3390/su11072089
15. Calder, J. The Calculus of Variations. University of Minnesota School of Mathematics, 2024. p.178 https://www-users.cse.umn.edu/~jwcalder/CalculusOfVariations.pdf
16. Peterson K. Ozili, P. Sustainability and Sustainable Development Research around the World. In Managing Global Transitions, 2022. DOI: 10.26493/1854-6935.20.259-293
17. National Academies of Sciences, Engineering, and Medicine. Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions. 2024. Washington, DC: The National Academies Press. https://doi.org/10.17226/25931.
18. Matthies, A., Stamm, I., Hirvilammi, T., Narhi K. Ecosocial Innovations and Their Capacity to Integrate Ecological, Economic and Social Sustainability Transition. Sustainability, 2019. 11, 2107; doi:10.3390/su11072107
19. Mishra, M. The Kuznets Curve for the Sustainable Environment and Economic Growth 2020, https://hdl.handle.net/10419/216734
20. Sukumar, N., The Role of Stock Exchanges in Fostering Economic Growth and Sustainable Development, 2017. www.unctad.org
21. Zheng, J., Mi, Z., Coffman, D`M., Shan, Y., Guan, D., Wang, S. The Slowdown in China's Carbon Emissions Growth in the New Phase of Economic Development; One Earth 2019, 1, 240–253 Published by Elsevier Inc. https://doi.org/10.1016/j.oneear.2019.10.007
22. Voronov, A. Analytical models and methods for quality management at sustainability of product life cycle. E-library: Vestnik UNECON, 2018, 265 – 270 https://elibrary.ru/item.asp?id=35399987 (in Russian).
23. Voronov, A. Life cycle approach for sustainability competence assessment. In T. Issa (editor), Sustainability awareness and green information technologies (ch.2). Springer, 2020. https://doi.org/10.1007/978-3-030-47975-6_2.
24. Voronov, A. (2024). Imagining on The New Development Concept of Life-Long Learning Towards Carbon Action Plan. Green and Low-Carbon Economy. 2024, https://doi.org/10.47852/bonviewGLCE42022905
25. SDG Indicators (Indicator 9.4.1: CO2 emission per unit of value added) https://unstats.un.org/sdgs/metadata/

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