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The Optimal Use of Natural Resources in Light Of Intergenerational Equity*

Alicja M. GRACZYK

Wroclaw University of Economics and Business, Wroclaw, Poland

Correspondence should be addressed to: Alicja M. GRACZYK, alicja.graczyk@ue.wroc.pl

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Abstract

This paper provides an overview of those economic models of resource management which bear associations with the realization of the principle of intergenerational equity as the key element in effective implementation of the sustainable development postulates. Sustainable development entails the preservation of capital for future generations – most particularly: the natural capital. The paper represents an attempt at identifying those of the presently adopted economic models of resource management which are best suited to reinforce the realization of the idea of intergenerational equity and the durable qualities of sustainable development. The following methods were employed in the study: identification, critical analysis, comparative analysis, and expert evaluation of economic models. Based on definitions of fundamental concepts established in the initial section of the paper, the author identified those of the presently adopted models which ensure the realization of the postulate of intergenerational equity. Three main models were identified: the utilitarian criterion, the Rawls criterion, and the Chichilnisky criterion. These were analysed and evaluated for their utility, validity, and conformity with the principle of intergenerational equity. The findings of the study are in favour of the Chichilnisky criterion as best suited for the realization of the idea of equity, both inter- and intra-generational, as it takes into account the interests of both the present and the future generations. This criterion was also found to best represent the durability aspects of sustainable development.

Keywords: sustainable development, generational equity, natural resources

Introduction and Research Methodology

Human population has overshot the Earth's natural regenerative capacity in the 1980s, up to the present value of nearly 30% (*Living planet*, 2008). Early analyses of global trends in human approach to economic activities date back to 1972, following the publication of *The Limits to Growth* by J. Randers. The author not only managed to provide an alarmingly accurate forecast of the world's development by the year 2052, but also presented a number of predictions related to the loss, depletion, and devastation of natural resources (Meadows, Randers, Meadows, Behrens, 2004) caused by the overly expansive economic exploitation and the growing anthropopressure. The latter was strongly accented by the author as the most important obstacle to the preservation of intergenerational justice (Randers, Green, 2012).

Development may only be considered sustainable if the present generations are not profiting at the cost of future generations. If we were to consume all of the accessible resources, future generations would be left with no chance for effective development. Limitation of the durability aspects of the natural environment involve degradation of its quality and the excessive use of its resources, including fossil fuels. With reference to the social aspects, it involves a generational credit (public debt) as collateral to be paid by generations to come.

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Environmental economists argue that the humanity has already reached an excessive level of wealth through anthropopressure. They believe that the continued presence of such trends will naturally lead to limitation of wealth. In the opinion of some economists, the present level of goods consumption (non-sustainable) may, in the short perspective, lead to conservation or even increase of income and wealth, but will result in irreparable damage to the environment in the foreseeable future, along with the consequential loss of social welfare far beyond the basic level of survival.

The above prognosis is the most pessimistic scenario, often referred to as the path of unsustainable development. If our objective is to ensure the highest possible level of sustainable development (represented by the horizontal line), the economists recommend taking prompt and decisive action to ensure effective change in our approach to resource management. This change may only be effected through the use of modern technologies with largely reduced environmental imprint (e.g. those based on renewable energy sources), with proper emphasis placed on preservation of scarce natural reserves, in line with the sustainability principle.

The realm of the economic theory of resource exploitation has stimulated the construction of models for social wealth maximization based on dynamic management of resources (with the inclusion of time factor). The paper presents an analytical overview of those of the available economic models of resource management which correspond with the realization of the principle of intergenerational equity, with the purpose of identifying the most suitable and effective embodiment of the equity principle and the durability aspects of sustainable development. The following methods were employed in the study: identification, critical analysis, comparative analysis, and expert evaluation of economic models. The next section of this paper provides definitions of the notions of generational equity, durability of development, and durability of natural resources, followed by identifications and evaluations of models that fulfil the principle of equity. The final section of this paper is a determination of an optimal model, in the context of practical realization of generational equity and durability of development.

Definitions

Sustainable development places emphasis on the following fundamental values (Hull, 2010):

- preservation of human species (anthroposphere) and civilizational progress;
- generational equity (both inter- and intra-generational) in natural resource utilization; the notion of equity bears strong associations with such values as: justice, tolerance, objectivity, equality, responsibility;
- the right to quality of life, including proper conditions for the effective execution and pursuance of such right;
- knowledge of capacities and limits of natural ecosystems and the entire biosphere;
- the value of systemic (holistic) approach, integrating knowledge of all environmental aspects and processes;
- ensuring that each intervention in natural environment receives effective social support and is conducted within the limits of ecosystems' natural capacity.

Support and preservation of generational equity in accessing and utilizing the natural environment and its resources (both in its inter- and intra-generational dimension) remains a crucial and fundamental principle of SD. The idea is a direct product of ethical deliberations related to the postulates of environmental economics. J. Pawlica in his *The fundamentals of ethics* defines SD as: 'equal and impartial opportunities of all society members in production and distribution of material and cultural property' (Pawlica, 1994). However, the above definition references only a narrow aspect of equity – namely, the *intragenerational equity*. Modern approaches emphasize a broader outlook, integrating both the intragenerational equity and *intergenerational equity*. The former provides support for the right of equal access of regions, groups, and individuals to the natural environment, and places focus on equal development of humans and natural ecosystems. This also includes inter-regional and intergroup justice (equity) of access to limited natural resources, and equalization of chances and opportunities of regions and local units in the satisfaction of their needs and requirements, both local, regional, and those pursued in a broader social context (Słodowa-Hełpa, 2013). Intergenerational equity, on the other hand, concerns the preservation of natural environment for future generations in a 'socially acceptable' condition; this includes natural environments as such, their basic resources (also fuels), and the wealth of other non-economic benefits offered (Fiedor, 2002). In contrast to the definition by J. Pawlica, this approach refers not only to property, but also to other freely accessible qualities of the natural environment (including non-pecuniary assets and those which – for some reason – cannot be managed effectively) (Becla, Czaja, Hałasa, Rumianowska, 2001).

In addition, a definition of equity in our context should also provide a proper representation of purely aesthetic and spiritual benefits of nature as well as proper recognition of various societies and communities (this includes also future generations). In its temporal dimension, our definition should not be reduced to the time of production and distribution of property or goods, but rather make a reference to the entire process, which also entails present and future utilization and access to resources, and the resource consumption processes that occur in the natural environment outside human control.

The principle of generational equity bears close associations with another element of the SD – namely, the principle of sustaining the natural capacity of environments (respecting the capacity limits of environments and improving their

resilience to anthropopressure). The effective realization of this principle requires protection and preservation of nature, while its operationalization places legislative or administrative limits on any human intervention made to the natural environment. It also bears strong associations with prophylactic and prudential approaches and with extensive examination of potential environmental effects and consequences of each planned intervention. As such, it accentuates the need to depart from practices of environmental lenience offered in exchange for pecuniary compensation paid by parties responsible for negative environmental effects (reformulation of the approach to the environmental penalties system) (Borys, 2005).

Durability in sustainable development

The concept of durable (lasting) development has been explored extensively by members of the Polish school of environmental economics (Borys, Fiedor, Czaja, Kiełczewski). According to B. Fiedor, durable development entails maximization of net benefits of economic development coupled with preservation of both quality and utility of natural resources in a long-term perspective. B. Fiedor puts emphasis on reduction of consumption to limits determined by environmental capacity, as an important condition for durable development ensuring preservation of environmental qualities and benefits for generations to come (Fiedor, 2002). D. Kiełczewski interprets durable development as an aggregate durability of all possible determinants of wealth increase (both quantitative and qualitative) in an unlimited time horizon, with their roles defined on the basis of applicable theories of economic growth (Kiełczewski, 2010). S. Czaja insists that the durability property be analysed in a temporal dimension, associated with the need to preserve development opportunities for a generation in a given time frame (Czaja, 2002). The concept of durable development is construed on the basis of durability principles. Each durability principle is described by the development durability variant (for instance, weak durable development corresponds with the principle of weak durability development) and by its specific approach to the interpretation of durability (anthropocentric vs. nature-centred perspective). Durability principles of SD serve to reflect and gradate the assorted approaches to capital management, in relation to the available potential for their substitution. The basic principles (also referred to in literature as levels of sustainability) are chiefly made in reference to potential for the substitution of anthropogenic capital (i.e. one produced by human intervention) and natural (environmental) capital (Fiedor, 2002) while referencing the limits of environmental tolerance for antropopressure, and serve to express their durability force RZ. Below are the four principles of capital durability (Hueting, Reijnders, 1998), as postulated by B. Fiedor (Fiedor, 1999) and T. Borys (Borys, 2005):

1. Weak durability principle (weak sustainability) – emphasizes the preservation of total value of a capital resource, without regard for its internal structure.
2. Responsive (moderate) durability (or the principle of limited capital substitution) – represents the next step in the reinforcement of development durability/sustainability. This approach places emphasis on preservation of both the total value of a capital resource and the integrity of its structure, i.e. the specific relations between its constituents (or, alternatively, on determination of relative proportions or minimal shares of the constituent elements, although without proper knowledge of actual limits or critical values of each type of such capital). This principle is widely accepted under the Keynesian environmental economics approach (Fiedor, 2002).
3. Strong durability principle (or the principle of capital complementarity) – this approach allows for substitution only within the bounds of each form of capital (to an equal value and of equal quality). Substitution across capital boundaries is not accepted. Each type and form of capital should be preserved independently of others. The principle is interpreted as follows: any depletion in a specific form or type of capital should be recompensed by an equal increase of this specific capital type or form.
4. Restrictive (radical or very strong) durability/sustainability principle – prevents depletion of any type of capital, including exploitation of non-renewable natural resources, while restricting the limits of renewable sources exploitation to a tempo dictated by their natural (annual) replenishment or reproductive capacity. This principle represents a radically nature-centred approach to sustainable development. Not a single constituent element of the environmental capital should be depleted in any way (in a quantitative or qualitative sense of the term).

Many western sources employ a distinction of two durability principles only: the weak, and the strong, without the transitory variants (Goodstein, 2014; Tietenberg, 2012). The weak sustainability, in the Western approach, is interpreted in a similar manner: as potential for substitution between various forms of capital, while the use of the strong principle is typically defined in term of non-depletion of a basic natural capita, such as the ozone layer. Other foreign sources distinguish four such principles: very weak, weak, strong, and very strong. Tus, *very weak sustainability* or *slow sustainability* (Solow 1986; Solow 1974) requires that the *per capita* consumption is retained over time. The *very weak sustainability*, in this context, is defined by stationary state conditions (Hediger, 2004).

Natural resources and Economic Models

Modern definitions of environmental resources embrace the following: natural resources (including air, water, soil, minerals, flora, and fauna), elemental forces, environmental valour (microclimate, landscape, and spatial value. Initially, the use of environmental resources was gratuitous, due to their abundance. With the continued and incessant expansion of the human species, some of them have become scarce, requiring us to adopt skilful management techniques. Presently,

environmental resources constitute an important element of the social welfare function. The present shape of the modern resource theory is based on paradigms postulated by T. Malthus and D. Ricardo, later developed and critically evaluated by J.S. Mill, H.J. Barnett, and Ch. Morse, J. Dembowski, and E. Zimmerman (Barnett, Morse, 2011; Dembowski,1989; Zimmerman, Erich 1964). The classical economic stream has brought us the concept of resource scarcity, where early 19th century is considered to be an onset of the irreversible depletion of natural resources; this has the effect of imposing upper limits to economic growth and social welfare increase. This concept is based on the assumed correlation between economic growth and resource accessibility, coupled with the effects of limited and finite supply, and the idea of natural resource availability as a natural limit to growth. Despite the fact that the first two notions have long been refuted by civilizational progress, the concept served as a fundament for the zero-growth approach postulated by the Club of Rome in their acclaimed 1972 report (*Limits to Growth*) (Meadows, 2004). The report is the most famous and globally recognized example of research based on the Malthus paradigm, presenting alternative paths for the utilization of fundamental Earth's resources, and assuming their constant accessibility and supply. It was forecasted that, at the rates of growth recorded at the time of the report with respect to global production of food, industrial products, and services, as well as population trends, natural resource consumption patterns, ad growing anthropopressure, the next century will place humanity at the limits of their growth.

An important supplement to D. Ricardo's theorem was postulated by H.J. Barnett and Ch. Morse in the form of a dynamic theory of resources. Without questioning the resource limitation barrier, the theory rejected the assumption of physical limitation of resource availability. Instead, it placed the main emphasis on the associated cost of such exceedingly limited resources (Edwards, 1987). According to H.J. Barnett, resources are made available, rather than being given (Barnett, Morse, 2011) – the popular interpretation of this is that meeting the needs of human population is superior to the very existence of any resource.

The subject of resource distribution between present and future generations is at the core of many economic models. In this context, it may be useful to provide a critical evaluation of the utilitarian criterion (Bentham's utility principle) and J. Rawls' criterion of justice as fundaments for the development of many consecutive models tackling the problem of intergenerational equity.

Rawls principle of intergenerational justice and the utilitarian criterion

Implementation of the principle of intergenerational equity is a difficult endeavour. It requires us to make decisions on what we can do without and estimations on how much of it we are willing to part with in the process of satisfying our needs, to ensure that the next generation shall have equal opportunities to pursue theirs. Firstly, we need to remember that, in accordance with the rules of compound interest, even small annual bequests may – over a span of a century – amass to enormous values, to the irrecoverable loss of the entire generation. Such losses may generate other effects, such as reduction of investment – these may be looked down upon by future generations. Secondly, it may be difficult to estimate the future value of any resource turned down by the present generation as their bequest for generations to come. Even basic approximations of these values require the use of a discount rate in by-period comparisons.

The utilitarian criterion (the classical criterion of division), as the name suggests, can be traced back to the *utility* concept introduced by J. Bentham, the founder of modern utilitarianism. Utility can be expressed by the following formula (Riley, 1970):

$$\max V(t)= \int_{t}^{\infty} U[C(k)]\cdot e^{-g\cdot(k-t)}dk \qquad (1)$$

where:

V(t) – discounted sum of utility over *t* time,
U – the utility function, related to consumption by future generations,
C(k) – consumption vector of the k^{th} generation,
g – social rate of temporal preferences (positive).

According to this criterion, the aim behind distribution of resources is to provide maximum welfare over time perceived in a holistic perspective. The rate of discount is related to: the rate of technological progress, general saving proclivity, cultural determinants. The utilitarian criterion does not impose any other restrictions for the estimation of utility levels for any given unit or generation; a loss incurred at any point in time (by any single generation) may be balanced by a welfare increase at a later time (Jakubczyk, 2002).

Rawls criterion of intergenerational justice (Rawls, 2003) stems from Kant's formulation of the categorical imperative "act only in accordance with that maxim through which you can at the same time will that it become a universal law"(Kowalik, 1997). In Kant's opinion, young generations were abundant in welfare – a fruit of their fathers' sacrifice

– without giving anything in return. Hence his appeal for a just distribution of welfare between generations, involving equalization of living standards while placing less significance on the actual level of such standard (Tatarkiewicz,1983).

According to J. Rawls, the sole pursuance of individual interest serves to distort the perception of economic processes. Decisions should be made on the basis of rational arguments and the principle of justice, assuming impartiality in the sense of departure from specific properties and characteristics of individual generations, without favouring any group over others.
J. Rawls believed that differences in welfare distribution could only be accepted if their use were dictated by the need to improve the condition of the poorest (Jakubczyk, 2002). His postulate involved a max–min principle construed on a critical evaluation of the utilitarian criterion, assuming that maximization of social welfare could only be achieved through increasing the utility of the poorest segment of a given generation (Pieńkowski, 2013):

$$W = \min (U1, U2, \ldots Un) \qquad (2)$$

The shape of Rawls function is consistent with the shape of curves illustrating consumer indifference towards perfectly complementary goods which are always consumed in equal proportion. Social welfare will remain unchanged if utility increase is observed only in one of the studied generations. Only equal change of utility in both generations will produce effective value increase of social welfare by transiting to a curve of a higher order. J. Rawls postulated that analyses of intergenerational equity should be based on the use of the so-called balance of expectations of an average individual towards their parents, and their proclivity to make sacrifices for their children. The max–min principle and its use in the capital accumulation process were met with a critical response by Solow (Solow, 1986). In his opinion, the most important limitation of the above principle is the requirement of departure from an initial level of resource stock (supply, availability) that warrants maintenance of a socially acceptable living standard (i.e. relating the welfare level to initial conditions and initial availability of resources (Cassidy, Koumpias. , Liang. Zhou, 2011). If such a provision is not met, the capital will not be accumulated, and the living standards will remain at their lowest, reinforcing the social inequality trends. The above limitation is also accented by other experts in environmental economics as an important obstacle to economic growth (Dasgupta 1973). The above view is also doomed to fail in two specific scenarios: firstly – if we supplement the model by including rapidly depleting resources, unless the cross-price elasticity of demand related to substitution between natural resources and renewable capital resources is equal or greater than one; and secondly: if we adopt this principle to an economy characterised by zero natural population growth (in this case, the emergent unlimited technological progress may produce the need for future generations to restrain their consumption levels).

Fig. 1 presents a comparative evaluation of the utilitarian criterion and the Rawls criterion. Under the utilitarian criterion, limitation of consumption patterns of all generations increases the utility function for the generations to come, allowing them to pass the U** level approached asymptotically by the society. The shape of the utilitarian curve suggests also that total utility values (U) of earlier generations initially follow a rapid growth curve. This trend is continued until certain values of the constant factor of capital accumulation are passed. Although later generations benefit from higher total utility values, but the pace of their increase decreases over time, and they may even diminish in value (the end segment of the curve). After adopting the max–min principle, the resulting distribution of welfare between generations will be more just (the U* plot).

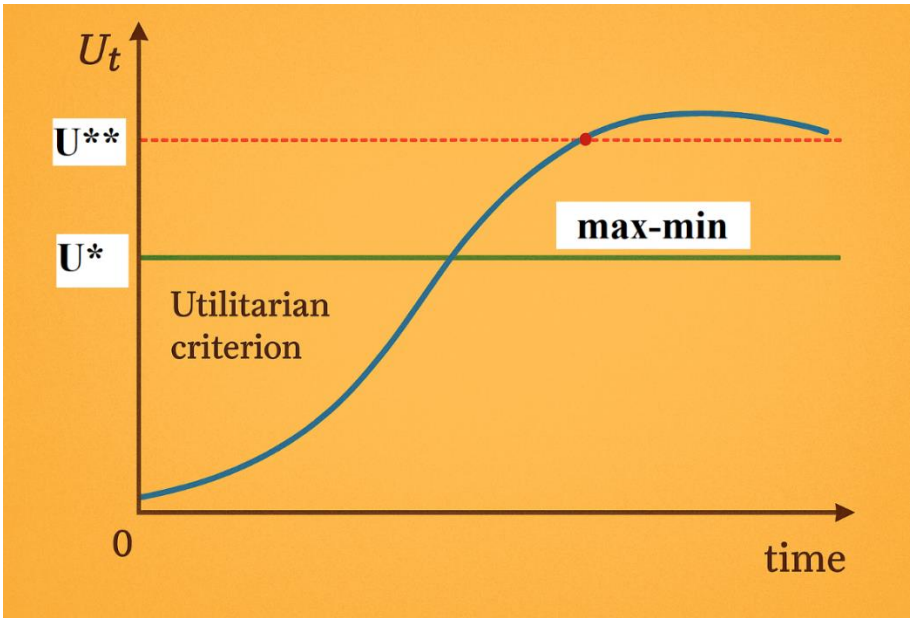

Fig.1. Utilitarian criterion and the Rawls criterion max–min

Source: Own elaboration based on: (Asako,1980).

Implementation of Rawls criterion involves departure from the assumptions of neoclassical economics expressed by Eugen von Böhm-Bawerk (Böhm-Bawerk, 1930), where economic units are deemed to always display preference for current consumption (welfare) rather than place care in consumption opportunities of future generations.

Utility discount and the Chichilnisky criterion

In accordance with Rawls theory, utility is a value measuring the fulfilment of human needs. Discounting, in this context, involves reduction of each future value by a constant factor to properly reflect the effect of time passage; this also applies to the value of utility. However, the value of a discount rate is also a reflection of preferences of the present generation.

Criterions for the selection of a development path based on traditional economic analyses are calculated from the postulate of maximizing the sum of discounted utility left to future generations (Żylicz, 2014):

$$\Sigma_{\infty t=0}\, ut /(1+ \delta)t \qquad (3)$$

where:
ut – utility (welfare) of t^{th} generation,
δ – discount rate.

The above optimum does not fulfil the postulate of durability, since any constant and positive value of δ will produce arguments to support the sacrifice of welfare of future generations to ensure the optimization of wealth for the present generation. This comes as an obvious contradiction of the sustainability principle, as the interests of the present generation take precedence over those of generations to come.

In 1996, Graziela Chichilnisky, an American economist, formulated a promising idea of a revised criterion, hereinafter referred to as the *Chichilnisky criterion* (Żylicz, 2014):

The new criterion is a combination of the sum of discounted utility approach and the limits approached by non-discounted utility for future generations. The first part of the sum of index w0, namely:

$$\Sigma_{\infty t=0}\, ut /(1+ \delta)t \qquad (5)$$

represents a measure of utility for generation *t*. If this part of the sum is assigned with priority weight in the calculation of index w0 (in this case, the α will approach 0), then the limitation of resources left to future generations obtained by increasing their supply to present generations will have the effect of increasing the measure of utility, in breach of the idea of sustainable development. However, if the decisive weight in the calculation of index w0 is assigned to the other part of the sum (in this case, the α will approach 1), as in:

$$\lim_{t\to\infty} ut, \qquad (6)$$

then it may be observed that, by referring this part of the w0 index to future events and by discarding the welfare of past generations (including the present generation choosing to save natural resources for future generations), we also depart from the postulates of sustainable development. Only proper combination of the two elements, culminating in calculation of the w0 index offers proper observance of sustainability postulates. It must be remembered that the value of α is set in advance. G. Chichilnisky provided evidence of the fact that each path of development that fulfils any rational definition of sustainability may be derived from her criterion after assigning certain weights to α and 1 – α and on assumption that the δ discount rate should not be set at a constant value but rather approach zero with time. This is a very special case of economic optimization, one that allows for a decidedly non-obvious solution, but allowing for proper satisfaction of the sustainable development criterion.

Limitations of research on equity criteria

In conclusion of the analytical evaluations presented herein, it must be noted that each of the above criteria of intergenerational equity has its own limitations in application contexts. For instance, one cannot make educated guesses on consumption preferences of future generations. It is not clear that our present sacrifices with respect to the use of natural resources will have any tangible effect on their welfare and if they will be appreciated. Future generations may also display quite different approaches to natural resources from the context of their needs. At present, it seems that great value will be placed by them on natural environment and wildlife, rather that the anthropocentric capital. Also, it seems futile to predict the future progress of technology. The value of resources preserved for future generations may exceed those needed for satisfaction of their needs or – on the contrary – suffice for a few years only. Lastly, it may be difficult to establish points of transition between consecutive generations (it is, after all, a continuous process). In effect, we cannot possibly state with any degree of confidence whether our generation is still that of parents amassing resources for our children, or that of the offspring, involved with consumption of wealth passed to us.

Conclusions

Intergenerational equity constitutes a central objective in numerous economic models, particularly those rooted in environmental economics, natural resource economics, and environmental econometrics. Among the foundational frameworks are the utilitarian criterion, which seeks to maximize aggregate welfare across generations, and the Rawlsian criterion, which emphasizes the equitable distribution of welfare irrespective of its absolute level. The utilitarian approach, while comprehensive in scope, tends to overlook disparities in living standards between generations, assuming that welfare gains in future populations can offset historical deficiencies. Conversely, the Rawlsian perspective prioritizes fairness across generational cohorts but inadequately accounts for technological advancement and its implications for societal progress.

In response to these limitations, environmental economics has introduced the sustainability or durability criterion, which posits that future generations possess an inherent right to living standards that are at least equivalent to those enjoyed by the present generation. This normative stance aligns closely with the principles of sustainable development. The Chichilnisky criterion offers a more integrative framework, balancing the interests of both current and future generations and thereby providing a more nuanced representation of intergenerational equity.

In the context of the European Union's environmental and climate policy, these theoretical constructs can be translated into actionable strategies. The following recommendations illustrate how intergenerational equity can be operationalized within the EU policy framework:

1. Alignment with Climate Neutrality Objectives: Economic planning should be harmonized with the EU's commitment to achieving climate neutrality by 2050. This entails prioritizing investments in renewable energy infrastructure, enhancing energy efficiency, and accelerating the transition away from fossil fuels.
2. Internalization of Environmental Externalities: The application of market-based instruments such as carbon pricing, emissions trading schemes (ETS), and environmental taxation is essential to ensure that the environmental costs borne by current generations do not compromise the welfare of future ones.
3. Support for Green Innovation and Technology Diffusion: Public and private sector collaboration should focus on fostering innovation in clean technologies and facilitating their equitable dissemination across member states and generational cohorts.
4. Institutionalization of Sustainability in Public Finance: Sustainability criteria should be embedded in public procurement and investment decisions, ensuring that long-term environmental impacts are systematically evaluated and mitigated.
5. Promotion of Environmental Literacy and Civic Engagement: Educational initiatives and participatory governance mechanisms should be strengthened to cultivate a culture of sustainability and long-term responsibility among citizens.
6. Monitoring and Evaluation through Robust Indicators: The use of sustainability metrics, such as those employed in the European energy and climate policy, is critical for assessing progress and informing adaptive policy responses.

By integrating these practical measures into economic modeling and policy design, the European Union can more effectively uphold the principle of intergenerational equity, ensuring that environmental stewardship and socio-economic resilience are sustained across temporal boundaries.

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