ISSN: 2710-0588

An Exploration of the Strengths and Limitations of Utilitarianism in Engineering Practice

Yao He[1,*], Jiayu Wei[1]

[1]School of Economics and Management, Southwest Petroleum University, Chengdu 610500, China

[*]Corresponding author email: hhy06hyy@163.com

Abstract

Utilitarianism centers on the greatest happiness and adheres to the principles of consequentialism, utilitarian calculus and impartiality. Its pursuit of efficiency and benefits, compatibility with quantitative analytical tools, and ethical justification for collective decision-making enable its in-depth alignment with engineering practice, making it a vital ethical framework for engineering decision-making. In engineering practice, utilitarianism sets a value orientation centered on public interests, optimizes resource allocation, and facilitates technological innovation and progress. The comprehensive flood control, power generation and shipping benefits of the Three Gorges Project serve as a typical example. Nevertheless, utilitarianism bears prominent limitations. It tends to overlook individual rights and the interests of minority groups and triggers imbalances between short-term and long-term interests. Furthermore, uncertainties in the prediction of engineering consequences escalate the risks of its application, and the Fukushima nuclear power plant accident has revealed the hazards arising from the one-sided pursuit of utility. Therefore, diverse ethical theories such as deontology and virtue ethics should be introduced. It is essential to strengthen responsibility ethics and full-life-cycle risk management, and improve mechanisms for public participation and democratic decision-making, so as to promote engineering practice to realize the coordinated development of economic benefits, social equity and environmental sustainability.

Keywords

Utilitarianism; Engineering Ethics; Engineering Decision-Making; Social Responsibility; Risk Management.

1. Introduction

The greatest happiness principle advocated by utilitarianism has become the dominant ethical paradigm in engineering decision-making due to its pursuit of efficiency and overall benefits, providing a core value basis for the evaluation of major projects. Nevertheless, the limitations of this ideology have become increasingly prominent in practice. Issues such as neglect of individual rights and misjudgment of long-term risks have aroused extensive ethical controversies. This paper conducts a dialectical analysis of the dual impacts of utilitarianism in engineering activities, and explores the construction of a fairer framework for engineering decision-making by integrating diverse ethics, strengthening risk governance and public participation, so as to promote the coordination of economic benefits and social responsibility in engineering practice.

ISSN: 2710-0588

2. The Core of Utilitarianism and Its Connection with Engineering Practice

2.1. The Core Principles of Utilitarianism

Jeremy Bentham, the great British utilitarian philosopher of the 19th century, held that the inherent value orientation of "utility" is "the greatest good for the greatest number" [1], which constitutes the fundamental principle of utilitarianism. As a consequentialist theory, it maintains that the sole basis for evaluating the ethical value of an action lies in its actual consequences. It advocates utilitarian calculus, proposing to compare alternative courses of action by quantifying and aggregating the pleasure and pain of all relevant subjects. Meanwhile, it emphasizes impartiality, requiring decision-makers to consider the rights and interests of all affected parties equally. John Stuart Mill further distinguished between the quality and quantity of pleasure. He argued that pleasure should be differentiated in both qualitative and quantitative dimensions, and pointed out that utility as the standard of conduct refers not only to pleasure but also to happiness. Happiness serves as the moral criterion of behavior and represents a complex holistic concept containing multiple elements [2]. Mill's arguments further enriched and perfected this ethical system.

2.2. The Inherent Compatibility between Utilitarianism and Engineering Practice

The creed of utilitarianism is the Greatest Happiness Principle, namely the greatest happiness of the greatest number. What utilitarianism pursues is not individual happiness, but the happiness of all people within the community. Therefore, theoretically, the idea of utilitarianism is desirable, and the difficulty lies in its transformation from theory into practice [3].

In the context of engineering practice, utilitarianism offers clear and operable evaluation logic for engineering scheme selection and benefit assessment, guiding engineering projects to generate greater overall social value. Utilitarianism discusses morality on the basis of real economic relations and takes utility as the criterion for evaluating human conduct. By emphasizing the practical consequences of moral acts, it provides a straightforward operational benchmark for engineering decision-making and effectively boosts social and economic development. Accordingly, utility inevitably becomes an ethical criterion and dimension governing engineering decision-making [4]. Nevertheless, the inherent flaws of this ethical paradigm keep emerging in engineering activities. Excessive emphasis on aggregate benefits tends to neglect the legitimate rights and interests of minority groups. In addition, utilitarian calculus cannot fully account for impacts that are hard to monetize, such as long-term ecological risks and intangible damages. This indicates that when utilitarianism is adopted to guide engineering decision-making, the standard of utility maximization cannot be relied upon exclusively. Supplementary ethical perspectives are required to balance collective gains and individual equity, as well as short-term benefits and long-term sustainable development.

3. The Positive Roles of Utilitarianism in Engineering Practice

3.1. Providing a Clear Value Orientation

Utilitarianism endows engineering practice with a value orientation centered on public interests. Engineers and decision-makers face numerous alternatives and choices in engineering activities. Guided by the greatest happiness principle of utilitarianism, they are able to take public interests as the primary consideration. This helps align the objectives of engineering activities with the overall interests of society and prevents engineering projects from serving only a small number of people or specific interest groups.

ISSN: 2710-0588

In the construction of urban infrastructure, utilitarianism guides engineers and decision-makers to prioritize the satisfaction of basic public needs, such as access to safe drinking water, reliable power supply and convenient transportation systems. Cost-benefit analysis of different engineering schemes is adopted to select the option that brings the greatest benefits to the greatest number of people. When constructing urban sewage treatment plants, factors including treatment capacity, treatment efficiency, construction costs and operating costs are comprehensively evaluated to effectively improve urban water environment quality and protect public health. Meanwhile, the scheme should be economically viable and enable rational utilization of resources. Such a value concept oriented toward public interests helps strengthen public trust and support for engineering activities and facilitates their smooth implementation.

3.2. Promoting the Efficient Allocation of Resources

Resources available for engineering activities are limited. Utilitarianism lays stress on the consequences and benefits of actions and pursues the goal of achieving the greatest happiness for the greatest number. Accordingly, when allocating resources, engineers and decision-makers can conduct comprehensive deliberation from the perspective of overall benefits, weigh the advantages and disadvantages of various projects and schemes, and allocate resources to sectors and links capable of generating maximum benefits.

In large-scale engineering projects such as infrastructure construction and energy exploitation, utilitarianism guides decision-makers to carry out comprehensive project feasibility assessment covering technical, economic and environmental feasibility. Cost-benefit analysis is adopted to identify the expected benefits and costs of projects, so as to select projects whose benefits outweigh costs and can realize the optimal allocation of resources.

Utilitarianism encourages attention to resource conservation and recycling in the implementation of engineering activities. In construction engineering, energy-saving technologies and materials can be adopted to improve the energy efficiency of buildings. Meanwhile, the recovery and reuse of construction waste can be promoted to reduce the exploitation of natural resources and realize resource recycling. Such efficient allocation and rational utilization of resources help improve the economic benefits of engineering activities and alleviate environmental pressure, thereby realizing the coordinated development of the economy, society and the environment.

3.3. Promoting Engineering Innovation and Technological Progress

Utilitarianism emphasizes the pursuit of the greatest happiness for the greatest number. With the continuous development of society, demands for more efficient transportation systems, more convenient communication technologies, more comfortable living environments and other amenities keep rising. To satisfy these growing needs, utilitarianism inspires engineers and researchers to continuously advance engineering innovation and technological progress.

3.4. Analyzing Practical Cases

The Three Gorges Project is one of the world's largest water conservancy hubs, boasting comprehensive benefits including flood control, power generation and navigation. From the perspective of utilitarianism, the construction of the Three Gorges Project embodies the pursuit of the greatest happiness for the greatest number.

In terms of flood control, the middle and lower reaches of the Yangtze River are densely populated and economically prosperous, yet plagued by frequent floods throughout history. The Three Gorges Reservoir possesses formidable flood regulation and storage capacity. It can impound upstream floodwater and greatly alleviate flood control pressures in the middle and lower reaches, safeguarding people's lives and property along the river. Through coordinated operation with dykes and flood diversion and storage facilities, the flood control standard of the Jingjiang River section has been upgraded from a 10-year return period to a 100-year return

ISSN: 2710-0588

period. The project effectively mitigates the adverse impacts of floods on regional development, enables residents to live and work in peace and contentment, and improves the overall social welfare of the region.

With regard to power generation, the Three Gorges Hydropower Station has a huge installed capacity, with an annual power output exceeding 100 billion kilowatt-hours, benefiting half of China [5]. The supply of such clean electric power not only meets the electricity demand for economic development in East China, Central China and other regions, guaranteeing stable power supply for local industrial production and household consumption, but also reduces reliance on traditional fossil fuels and cuts carbon emissions. It is of great significance for easing energy shortages and addressing climate change.

In terms of navigation, the Three Gorges Project has improved navigation conditions on the Yangtze River, enabling ten-thousand-ton fleets to sail directly to Chongqing. This promotes the development of waterborne transportation in the Yangtze River Basin, strengthens economic links and trade between regions, lowers logistics costs and improves transport efficiency, facilitating coordinated regional economic development. The advancement of shipping drives prosperity in port logistics, tourism and other industries along the river, creates more jobs and income opportunities for local residents, and elevates overall social welfare.

4. The Limitations of Utilitarianism in Engineering Practice

4.1. Ignoring Individual Rights and the Interests of Minority Groups

Utilitarianism takes the pursuit of the greatest happiness for the greatest number as its core goal. Consequently, overall interests are often prioritized in engineering practice, which may lead to the neglect of individual rights and the interests of minority groups to a certain extent. When making decisions, utilitarianism tends to select schemes that yield the maximum aggregate benefits, even if they may infringe upon the rights and interests of certain individuals or minority groups.

The construction of some infrastructure projects such as expressways and railways may pass through ethnic minority settlements or ecologically fragile areas. In pursuit of smooth project implementation and overall benefits, local ethnic minorities' cultural traditions and lifestyles as well as the ecological environment may suffer damage. Although these projects exert positive effects on national or regional economic development and social progress from a macro perspective, the rights and values of the affected minority groups and ecological surroundings are overlooked. Such disregard for individual rights and minority interests may trigger social contradictions and conflicts and undermine social harmony and stability.

4.2. Unbalancing Short-term Interests and Long-term Interests

Utilitarianism in engineering practice generally focuses on calculating and pursuing measurable immediate benefits, which tends to create an imbalance between short-term and long-term interests. In the specific process of engineering decision-making, since short-term interests are relatively easier to perceive and evaluate, decision-makers may tend to select alternatives that deliver remarkable benefits in the short run, while ignoring the long-term impacts of engineering activities.

The imbalance between short-term and long-term interests exists in certain urban planning and construction projects. In pursuit of immediate economic gains, some cities carry out excessive land development and blindly construct high-rise buildings and large-scale commercial projects, neglecting urban ecological protection, infrastructure support and public service facilities. As cities expand, problems including traffic congestion, environmental pollution and declining residents' quality of life gradually emerge, posing severe challenges to urban sustainable development. To a large extent, these issues arise because engineering

ISSN: 2710-0588

decision-making merely concentrates on immediate economic returns without adequate consideration of long-term interests.

4.3. Facing Uncertainty in Consequence Prediction

The application of utilitarianism in engineering activities relies on the prediction of behavioral consequences. The optimal scheme is selected by comparing the potential outcomes of different actions. Nevertheless, considerable uncertainty exists in consequence prediction within practical engineering practice, which creates substantial obstacles to the application of utilitarianism.

Engineering activities involve complex interrelated factors spanning technology, natural environment, socio-economic conditions and politics. The interactions among these factors make it extremely difficult to accurately forecast engineering consequences. Engineering projects may damage biodiversity. Large-scale projects such as major dam constructions often exert profound impacts on local ecological environments and biodiversity [6].

Complicated geological conditions may trigger unexpected troubles during construction, for instance unstable foundations and mountain landslides. Hydrological variations can affect the power generation efficiency and flood control capacity of hydropower stations. Changes to ecological environments may generate unforeseeable impacts on surrounding flora and fauna communities. Improper resettlement of migrants may lead to social conflicts. The uncertainty of these factors makes it hard to precisely predict all kinds of consequences brought by the construction and operation of hydropower stations.

4.4. Analyzing Practical Cases

The Fukushima nuclear power plant accident is a shocking major engineering disaster, which profoundly reflects the limitations of utilitarianism. From a utilitarian perspective, the construction and operation of the Fukushima Nuclear Power Plant aimed to secure Japan's electricity supply, maintain regional energy stability and support economic development by virtue of efficient nuclear energy. On the surface, this aligned with the value goal of achieving the greatest happiness for the greatest number. Nevertheless, the project one-sidedly pursued short-term overall benefits while ignoring potential safety risks as well as long-term hazards to the ecosystem and human health. During the planning phase, the threat of tsunamis was underestimated, and the design standards for earthquakes and extreme tsunami disasters were insufficient. To cut costs, Tokyo Electric Power Company weakened safety management and concealed equipment hazards over a long period.

When the earthquake and tsunami struck, the emergency backup power system failed, the core cooling process was interrupted, resulting in core meltdown and hydrogen explosions, which further damaged the containment barriers. After the accident, massive radioactive contaminants leaked out, severely polluting local water, soil and the atmosphere and destroying the regional ecosystem. Long-term radiation poses threats to the physical health of nearby residents. This case demonstrates that one-sided application of utilitarianism in engineering decision-making, with excessive emphasis on short-term overall benefits and disregard for long-term risks, will ultimately lead to catastrophic consequences.

5. Strategies for Addressing the Limitations of Utilitarianism

5.1. Introducing Diverse Ethical Theories

To effectively tackle the limitations of utilitarianism in engineering practice, introducing diverse ethical theories constitutes a viable strategy. Deontology emphasizes the inherent rightness of actions, holding that certain behaviors possess intrinsic moral value and ought to be followed regardless of their consequences. In engineering decision-making, it is necessary

ISSN: 2710-0588

to consider not only whether the outcomes of actions can achieve the greatest happiness for the greatest number, but also ensure that actions comply with fundamental moral duties and principles. During engineering construction, a project cannot disregard the protection of surrounding residents' rights merely for its substantial economic benefits. Instead, decision-makers should fully respect residents' rights to know, rights to participate and reasonable demands for compensation. Following deontological principles safeguards individuals' basic rights. Integrating deontology with utilitarianism can remedy utilitarianism's defect of neglecting individual rights and the interests of minority groups.

The integration of contractarianism and utilitarianism is also of great significance. Contractarianism maintains that social order and moral norms are formed on the basis of contracts and agreements among people. In engineering activities, the introduction of contractarianism can clarify the rights and obligations of all stakeholders and ensure that engineering operations proceed under fair and impartial rules. In the bidding process of engineering projects, contracts and agreements define the responsibilities and rights of each party to prevent conflicts of interest and unfair competition. Meanwhile, contractarianism stresses the observance and performance of contracts, which helps improve the stability and reliability of engineering activities.

Virtue ethics can also provide valuable supplementation for engineering activities. Virtue ethics focuses on the character and moral traits of actors, arguing that ethical individuals demonstrate virtues such as honesty, integrity, courage and responsibility in their conduct. In engineering practice, cultivating engineers' virtuous character enables them to make more morally sound decisions when confronted with complex ethical dilemmas.

5.2. Strengthening Responsibility Ethics and Risk Management

Strengthening responsibility ethics and risk management is vitally important in engineering practice. Responsibility ethics requires engineers to clarify their duties and obligations in engineering activities. They shall be accountable not only for the quality, safety and benefits of projects, but also for society, the environment and future generations. Engineers ought to prioritize human life and health, ensure that engineering design and construction comply with safety standards, and prevent public harm caused by engineering accidents. Engineers also need to take responsibility for the environmental impacts of engineering activities, uphold the concept of sustainable development, proactively adopt ecological protection measures, reduce resource consumption and mitigate disturbances to ecosystems brought by construction. When implemented in the field of energy engineering, engineers should vigorously advance the research, development and large-scale application of clean energy, reduce the dependence of socio-economic development on traditional fossil fuels, cut carbon emissions, and achieve effective ecological and environmental protection.

Risk management is also an indispensable component of engineering activities. Effective risk management enables the identification, assessment and handling of various potential risks in engineering projects, lowering both the probability of risk occurrence and the severity of its impacts. Prior to construction, comprehensive risk assessment should be carried out for projects, and corresponding risk response strategies should be formulated. In terms of technical risks, technological research and innovation can be strengthened to improve the technical standard and reliability of engineering projects. For market risks, market research and forecasting can be conducted to formulate reasonable marketing strategies. As for environmental risks, environmental protection measures can be adopted to lessen environmental impacts. With regard to social risks, communication and negotiation with local residents and relevant stakeholders should be enhanced to gain their support and understanding.

ISSN: 2710-0588

During engineering implementation, a sound risk monitoring mechanism shall be established to detect and address risk incidents in a timely manner. Regular inspections and evaluations shall be conducted on project progress, quality and safety, and prompt countermeasures shall be adopted once problems are identified. Meanwhile, emergency plans need to be formulated to cope with potential emergencies and guarantee the smooth progress of engineering activities.

5.3. Strengthening Public Participation and Democratic Decision-making

Strengthening public participation and democratic decision-making plays a vital role in engineering practice. As direct or indirect stakeholders of engineering activities, the public have personal experience and understanding of the impacts brought by engineering projects and can provide abundant information and opinions. Public participation enables more scientific and rational engineering decisions and ensures that the interests and demands of all sectors of society are fully taken into account.

Public participation can also enhance public recognition and support for engineering activities and reduce resistance during project implementation. Involving the public in engineering decision-making helps citizens fully understand decisions that may harm their own interests, promotes a more prudent attitude in engineering decision-making, and ensures that public interests are considered comprehensively [7].

To realize public participation and democratic decision-making, a sound public participation mechanism needs to be established. Channels for public participation should be broadened, such as hearings, questionnaires and online platforms, so that the public can conveniently express their opinions and suggestions. During the project planning and decision-making stages, relevant information including project objectives, contents, technical schemes and environmental impact assessments shall be disclosed to the public in a timely manner to guarantee the public's right to know. Meanwhile, public opinions and suggestions should be treated seriously. Reasonable proposals shall be adopted with timely feedback provided to the public to cultivate a sense of participation among citizens.

6. Conclusion

Utilitarianism takes the pursuit of the greatest happiness for the greatest number as its core principle and emphasizes result orientation and quantitative calculation. It is highly consistent with the pursuit of efficiency, benefits and objectivity in engineering practice, and provides clear value orientation and ethical justification for engineering decision-making. It demonstrates prominent advantages especially in optimizing resource allocation, promoting technological innovation and demonstrating the macro benefits of large-scale public engineering projects. Nevertheless, its limitations emerge in complex engineering scenarios. One-sided emphasis on overall benefits tends to lead to neglect of individual rights and the interests of minority groups. Preference for measurable short-term gains may come at the expense of long-term sustainable development. Furthermore, inherent uncertainties within engineering systems make accurate consequence prediction difficult to achieve. The Fukushima nuclear accident stands as a tragic example of such limitations.

To address these limitations, engineering practice needs to move beyond the single utilitarian framework and adopt multi-dimensional strategies. First, diverse ethical theories such as deontology and virtue ethics should be introduced to remedy utilitarian calculation's disregard for human beings by respecting individual rights and upholding the bottom line of justice. Second, prevention-oriented responsibility ethics and full-life-cycle risk management ought to be strengthened to cope with uncertainties through prudent assessment and dynamic monitoring. Last but not least, it is critical to boost public participation and democratic decision-making. Procedural justice ensures that the interests of all parties are fully voiced and

ISSN: 2710-0588

weighed. As a result, engineering decisions not only pursue optimal outcomes but also withstand ethical scrutiny, ultimately achieving the in-depth integration of economic benefits, social equity and environmental sustainability.

References

[1] Xu, Q., & Liu, P. (2018). Dialectical analysis of Chinese and Western utilitarian political philosophy theories. Journal of Dalian Maritime University (Social Science Edition), 17(4), 93–98.

[2] Liu, Q. (2009). A review of research on Mill's ethical thoughts. Journal of Guangxi Normal University (Philosophy and Social Sciences Edition), 45(5), 25–30. https://doi.org/10.16088/j.issn.1001-6597.2009.05.004

[3] Dong, X., & Jiang, X. (2018). Ethical dilemmas and their solutions in engineering practice. Journal of Shenyang Institute of Engineering (Social Sciences Edition), 14(4), 461–467+480. https://doi.org/10.13888/j.cnki.jsie(ss).2018.04.004

[4] Qi, Y., Liu, Z., Zhao, Y., & et al. (2009). On the ethical dimension of engineering decision-making. Studies in Dialectics of Nature, 25(9), 49–53. https://doi.org/10.19484/j.cnki.1000-8934.2009.09.011

[5] Zhu, J. (2021). The Three Gorges Project: A national mega-project realizing a century-old dream. Grand Garden of Science, (14), 30–33.

[6] Zhao, M., & Jiang, X. (2017). Utilitarian roots of anomie in contemporary engineering ethics and their resolution approaches. Journal of Shenyang Institute of Engineering (Social Sciences Edition), 13(4), 513–519. https://doi.org/10.13888/j.cnki.jsie(ss).2017.04.013

[7] Dai, L. (2013). An analysis of engineering safety ethics from the perspective of engineers. Journal of Kunming University of Science and Technology (Social Sciences Edition), 13(5), 1–9. https://doi.org/10.16112/j.cnki.53-1160/c.2013.05.006.