

Participating Strategy of the Constructors in the Construction of Credit Transfer System in China

Zhen He, Tao Bu

Faculty of Education, Beijing Normal University, Beijing 100875, China

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Abstract The credit transfer system (CTS) is a complex learning and educational management system involving multiple entities such as learners, schools, and the government. Considering the external constraints, strategic assumptions, and payment assumption, and based on the benefit relationship among stakeholders, this paper attempts to construct a game-theoretic analysis framework of multi-stakeholder participation in the construction of a CTS, which focuses on the learning strategies of learners, the investment strategies of schools, and the management strategies of the government among the three entities considered in this study. Furthermore, the cost allocation and benefit demand of stakeholders to build a three-subject dynamic evolutionary game model have been analyzed. The authors also conducted a numerical simulation to analyze the decision-making mechanism of learners, schools, and the government under the CTS. The findings show that “strong participation” by learners in ability improvement, “active participation” by schools in building high-quality teaching resources, and “strong dominance” in supervision and support by the government together constitute the optimal strategy in constructing a suitable CTS.

Keywords credit transfer system (CTS), evolutionary game, learners, school, government

1 Introduction

As the global economy transitions from the traditional “industrial economy” to the “knowledge economy,” the rapid development of digitalization and information technology is continuously reshaping various sectors, particularly employment patterns and skill demands (Cha et al., 2023). New technologies such as artificial

intelligence, Big Data, and the Internet of Things are driving profound changes in the traditional economic structure at an unprecedented speed, quickly constructing an economic system centered on knowledge and innovation (Corrales-Herrero & Rodríguez-Prado, 2024). In this process, the requirements for skilled workers are also changing rapidly, emphasizing interdisciplinary knowledge integration, continuously updated skill, and higher adaptability (Suryadi et al., 2020). This transformation poses severe challenges to educational patterns, where the traditional “one-off learning” pattern relying on academic education and pre-work education is struggling to meet the demands of modern technology on jobs, limiting individuals’ continuous development in rapidly changing skill requirement (Kruss et al., 2015; Park et al., 2019). Therefore, the need to establish a lifelong learning system worldwide is becoming increasingly urgent to ensure that various workers can continuously enhance their competitiveness in a rapidly iterating knowledge economy. This urgency is further amplified by the rise of digital education, which provides the technological foundation and pedagogical flexibility necessary for such systems to thrive.

Against the background of developing technology, governments around the world are exploring the credit transfer system (CTS) as a powerful method to enhance national skill level and competitiveness. The CTS can be viewed as an institutional and managerial innovation within the broader digital education ecosystem, utilizing digital tools to record, store, and authenticate learning outcomes across diverse platforms and providers (Mason et al., 2001; Hotta, 2020). The CTS follows a useful approach that is currently receiving widespread attention, with its basic concept similar to the capital storage mechanism of a financial bank (Teichler, 2003). The CTS transforms the curriculum acquired by learners into “valuable” credits and deposits them into a bank-like system to create a personal credit account, thereby enabling the long-term accumulation of learning outcomes and allowing learners to redeem

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Tao Bu (✉)

E-mail: Tao_Bu@126.com

these credits for a certificate (Hotta, 2020; Toyne, 1979). The CTS not only allows learners to flexibly obtain and accumulate credits but also supports them in crossing fields and schools for learning and qualification transfer. In this system, learners' learning information, learning experiences, learning outcomes, and transfer records can all be recorded completely and clearly. Once the learning outcomes are certified by the system and meet established standards, learners can then exchange them for specific qualification certificates or academic certificates, providing an effective qualification verification channel (Perulli, 2015). For example, the Republic of Korea established the CTS in 1998, becoming one of the global leaders in this field (Park et al., 2019). The system allows learners to complete courses and accumulate credits in nontraditional educational environments, ultimately leading to the issuance of formal academic qualifications.

Building and operating a proper CTS is not easy. It is necessary to coordinate the relationship and benefit allocation of all stakeholders and to enlist their full and active support to participate in the construction of the CTS. Especially, the construction of a Chinese CTS still faces issues such as insufficient demand for credit transfer, lack of continuity in capital and teaching investment, unfair allocation of benefit, and inconsistent certification, leading to low enthusiasm from participants (Agelasto, 2010; Hotta, 2020). The construction of CTS is inseparable from the active collaboration of all constructors, especially in combining nonformal learning outcomes with traditional academic learning. The effective construction of CTS requires a high level of collaboration among schools, learners, the government, and other participants (Hotta, 2014; Ryan et al., 2018). How to meet the benefit requirements of stakeholders is the core issue in building a CTS. Otherwise, no matter how perfect the qualification framework, certification, accumulation, transfer, and evaluation standards are, it cannot promote the construction of a high-quality CTS.

However, the stakeholders in a CTS are inevitably divided on issues such as goal setting, division of responsibilities, benefits allocation, and cooperative relationships. Clarifying the mechanisms that connect the demands of and benefits to the stakeholders is conducive to optimizing resource allocation and promoting win-win cooperation among the constructors of CTS. Existing research has put forward suggestions on the collaborative relationships, benefit demands, and joint development of the CTS (Hotta, 2014; Ryan et al., 2018). Predicated on stakeholder theory, some scholars have indicated that the construction and operation costs of the CTS in the Republic of Korea are borne by multiple constructors, including national finance, learners, and enterprises (Park et al., 2019). However, there is no cost-benefit analysis for

each constructor, which is the key for each stakeholder to decide whether they want to participate in the construction of the CTS. Whether stakeholders wish to participate in the CTS, in what form they wish to participate, and to what extent they wish to participate are all decisions that must be made according to the cost-benefit analysis. Therefore, the question is what the costs and benefits for each stakeholder are and how to determine the equilibrium point between costs and benefits. The development of a high-quality CTS must meet the reasonable benefit demands of all constructors and establish a new mechanism for benefit allocation. This paper systematically analyzes the cost and benefit characteristics of learners, schools, and the government to clarify the rights and obligations of each participant and ensure the effective operation of CTS during the process of construction itself. In this paper, by constructing a dynamic evolutionary game model of learners, schools, and the government, the decision-making behavior and interactive relationships of multiple stakeholders under the CTS framework have been analyzed by applying numerical simulation method so as to provide scientific guidance and practical solution for the promotion and improvement of the CTS and finally achieve win-win outcomes for all constructors.

This study contributes to the literature by analyzing the construction mechanism of a CTS from the perspective of a game model, instead of focusing on the standard formulation, connotation, and development progress of CTS, and we found that a strategy combination of positive participation for all stakeholders in the game is the optimal strategy to maximize welfare. We built a three-subject dynamic evolutionary game model of CTS for the first time, based on the costs and benefits of each stakeholder, in which we only considered three stakeholders, namely, learners, schools, and the government. Other subjects such as colleges, educational institutions, associations, and enterprises were not included in the game model due to differences in quality and standards. In addition, we found three stable equilibrium points in the game model by using numerical simulation. The exclusive equilibrium point that learners choose is the "strong participation" strategy; schools choose the "active participation" strategy, while the government chooses "strong dominance" strategy, which are the dynamic optimal combinations contributing to the construction of CTS for a reference role.

2 Review of the Credit Transfer System

As early as 1979, Toyne in the United Kingdom proposed that all kinds of learning experiences of learners should be properly certified so as to prevent them

from repeating learning and try their best to obtain further educational experience and qualifications without wasting time (Toyne, 1979). In 1994, the first World Conference on Lifelong Learning was held in Rome, and the concept of lifelong learning was widely disseminated throughout the world (Edwards, 2004). Many countries take the concept of lifelong learning as the basic principle and take the realization of lifelong learning as the goal for setting education policies (Friebel, 2014; Merritt, 2008). Canada, Australia, The Republic of Korea, and other countries have begun to establish a variety of learning certification, evaluation, and transfer systems that adapt to their national conditions (Polidano et al., 2021). In Europe, the European Credit Transfer and Accumulation System (ECTS) was embedded in the Bologna Process in 1999, which sought to promote regional integration and enhance student mobility across countries with diverse higher education traditions (Karran, 2005). The development of ECTS was thus not only a technical solution for credit portability but also a political tool for advancing European higher education integration. The ECTS highlights the importance of building transparent and unified national standards to facilitate trust and recognition across different educational sectors, giving China valuable insights into how it might similarly construct a coherent framework that ensures comparability, credibility, and cross-institutional acceptance of credits. The CTS of the Republic of Korea was driven by the need to rapidly upskill the labor force amid industrial transformation (Park et al., 2019), its defining feature being the strong government role in recognizing nonformal and experiential learning and integrating it with formal education. For China, this case demonstrates a high degree of adaptability, considering its centralized governance structure and current emphasis on lifelong learning align closely with the government-led model of the Republic of Korea. The approach of the United States on credit transfer, by contrast, reflects a decentralized and market-oriented higher education system, where credit transfer is managed through bilateral agreements between institutions or state-level frameworks (Teichler, 2003). This system emerges from the tradition of institutional autonomy and diversity in higher education of the United States. Although the governance model of China differs significantly, the case of the United States underscores the importance of institutional flexibility and learner-centered arrangements, which can inform the efforts of China to encourage innovation in credit recognition and expand cross-regional learner mobility.

Beyond developed economies, the experiences of large developing countries such as India and Brazil provide additional lessons that are directly relevant to China. The National Education Policy 2020 of India introduced the Academic Bank of Credit, a digital

platform designed to allow students to accumulate and transfer credits across diverse institutions (Choudhary et al., 2024). However, the Indian model emerges in a context marked by vast regional disparities, a mix of public and private institutions, and limited standardization, with the challenge of providing lifelong learning opportunities to a large and diverse population while addressing inequalities in access to high-quality resources, which is less centralized, reflecting the federal structure of India and its reliance on digital platforms to overcome governance fragmentation. Similarly, Brazil has pursued credit recognition policies within its National System of Higher Education and vocational training frameworks, with an emphasis on bridging academic and technical pathways to promote social equity (Almeida et al., 2015). Brazil must contend with regional imbalances in education quality and the need to integrate nontraditional learners; so, Brazil relies more heavily on institutional autonomy and is influenced by market demand, resembling aspects of the model of the United States. Similar to China, both India and Brazil face challenges of large population size, uneven regional development, and the integration of nontraditional learners into formal education systems. China can draw on their lessons while emphasizing its own unique advantage of centralized governance and the open university framework to build a CTS that is both inclusive and strategically aligned with national development goals.

Taken together, these international experiences suggest that the CTS construction in China should not rely solely on descriptive borrowing but instead identify the interaction between system design and sociopolitical context. Specifically, European standardization, the Republic of Korea's governmental integration, the institutional flexibility of the United States, and the inclusive approaches of India and Brazil in large, stratified education systems provide complementary lessons. By synthesizing these approaches, China can address the challenges of low enthusiasm for credit transfer, inconsistent certification, and uneven distribution of educational resources, while aligning CTS development with the broader national strategies of lifelong learning and human capital enhancement (Jia & Im, 2023; Kim & Park, 2020; Mendoza-Chan & Pee, 2024).

The construction of a Chinese CTS started relatively late but has made significant progress. Since the 1990s, the Chinese CTS has roughly gone through three stages: theoretical exploration, construction practice, and improvement (Zhou, 2019). During this process, two types of systems have gradually formed: one relies on the Open University system at the national, provincial, city, and county levels, and the other relies on various training courses provided by colleges, educational institutions, associations, and enterprises for whom it is difficult to transfer credits across regions and

organizations. By the end of 2024, 25 provinces including its covered cities and counties had established a CTS based on the Open University and the construction of the CTS had achieved significant achievement, with Shanghai completing the credit transfer for over 100,000 people. The Shanghai CTS was officially started in 2012, becoming the first provincial-level CTS for lifelong learning in China. Currently, the Shanghai CTS has recorded the learning achievements of college graduates, community education learners, and workers, accumulating over 100 million records of credit data and establishing learning accounts for 5.2 million people. However, in terms of construction quality, the CTS still fails to fully serve the needs of socioeconomic development and meet individuals' education and learning demands. Different types of CTS, due to the lack of unified national and local standards, make it difficult to certify and transfer credits between different institutions or regions, increasing the complexity and uncertainty of learning outcomes (Agelasto, 2010).

Unlike the ECTS in Europe, which arose from the Bologna Process to advance cross-border higher education integration, or the CTS in the Republic of Korea, which was driven by labor market imperatives and a strong government role in recognizing informal learning, the CTS in China demonstrates unique features founded on its open university system. A prominent example is the practice of the Shanghai CTS, where the open university framework has been leveraged to coordinate diverse educational resources, integrate vocational and academic learning, and provide flexible learning pathways for adults and lifelong learners. Although European models emphasize regional standardization for mobility across sovereign states and the American models are largely market-driven and decentralized through institutional agreements, CTS construction in China remains government-led and systemically centralized, reflecting the broader governance tradition of the country. Especially, the integration of the CTS with the open university system highlights the commitment of China to lifelong learning and inclusivity, ensuring that nontraditional learners, working professionals, and adult students can accumulate, store, and transfer credits toward recognized qualifications.

Currently, the construction of CTS in China is mainly promoted by the government. However, the phenomenon that some learners store credits by ineffective learning often occurs due to the low quality of teaching course and supervision, which further hinders the construction of CTS and the realization of lifelong learning. The low participating enthusiasm of stakeholders leads to poor construction quality; the reason is that the benefits of the stakeholders in the CTS, including learners, schools, and the government, have not been effectively met. The providers of teaching

resources lack the motivation to carefully construct courses, so the learners lack the enthusiasm for in-depth learning. Thus, how to build a cost-benefit sharing mechanism for stakeholders is the key to the long-term positive development of the CTS.

3 Cost-Benefit Analysis of Stakeholders in CTS

The construction of CTS cannot be separated from the joint participation by each subject (stakeholder), but the participation by a single subject is easy to pay much of the costs and receive few benefits. For example, if the policy promotion and financial support by the government are not positively responded to by the learners and schools, it will be difficult to recover the economic benefits through the path of human capital improvement. Similarly, if the construction of a large number of teaching resources in a school does not receive a positive response from learners, it will be difficult for the schools to cover the construction cost through tuition fees, and it will be difficult for the government continue to support these subsidies. In addition, the active participation of learners cannot be separated from the teaching support provided by the schools and the credit certification provided by the government because, without these, it will not be possible to arouse the enthusiasm of learners. It can thus be seen that the stakeholders have formed a delicate game situation in the construction of CTS, and the decision of their active participation needs to determine the participation strategies of other stakeholders and form a stable equilibrium situation in multiple games. To study the cost-benefit issues and stability strategy between stakeholders in the construction of CTS, the research needs to first clarify the roles and positioning of each stakeholder, as well as the specific responsibilities and benefit demands in the system.

3.1 | Division of Benefits among Stakeholders

The application of stakeholder theory in the field of education has helped to comprehensively understand the demands and expectations of all stakeholders and formulate more scientific and reasonable educational policies and management measures (Donaldson & Preston, 1995). Previous studies mostly focused on higher education and vocational education. As the certification of learning outcomes in CTS is cross-regional and cross-organizational, we believe that the stakeholders of CTS are mainly composed of learners, schools which including the National Open University (NOU) and its affiliated institutions in different provinces, cities, and counties, and the government. It

is to be noted that the credit certification of other institutions is difficult to be certified by the CTS due to differences in quality and standards. However, the future inclusion of these institutions in CTS is also worth exploring.

The government is the promoter and supervisor in CTS. Currently, many countries and regions, including the Republic of Korea and the European Union, are actively promoting the construction of CTS under the leadership of the government. The government aims to promote the construction of a lifelong education system and a learning society through the implementation of CTS.

Learners are the target group in CTS. The *Investigation Report on the Progress of the Construction of China CTS 2020* (Jiangsu Open University & Jiangsu CTS Center, 2023) shows that rewarding individual learning results by improving academic qualifications in CTS is an important driving force to encourage all populations to participate in learning. This study takes all the population groups who want to acquire knowledge and improve academic qualifications as the participating subjects of CTS and does not specifically distinguish between vocational education or general education and skill training or academic training.

Schools are the main carrier of teaching in CTS and is also the core constructor of the Chinese CTS. The government department not only defines the construction task but also determines the responsibility, due to the deep cultivation in local continuing education of the NOU system over the years. In addition, in the process of teaching functional transformation, the NOU also undertakes a large number of nonacademic education tasks, which can provide learning or achievement certification, accumulation, and transfer services for learners across the country.

If the CTS is not established at the national level and relies solely on local administrative departments, schools, training institutions, and enterprises, extensive repetitive construction and certification costs will inevitably result in the waste of human capital, financial resources, materials, and time. Currently, there is a variety of teaching resources in the construction of CTS, which are available in various levels and types of institutions, but this practice also causes resource waste and certification difficulties (Souto-Iglesias & Baeza_Romero, 2018). Therefore, from the perspective of long-term sustainable development, the construction of a CTS in China should be a government-led initiative, coordinated by national departments, and eventually extended to the mutual recognition among CTSs.

In this system, each stakeholder has their own objectives and interests. Learners acquire knowledge through the CTS to meet their own pursuit of higher levels of education and skills. The government

completes the mission of providing high-quality labor and building a learning society by improving the quality of the CTS. Schools win a good social reputation and tuition, thus attracting more learners to participate by providing high-quality teaching resources, satisfying the pursuit of resource utilization efficiency and economies of scale, as well as the practice of social responsibility. The construction of a CTS must be a dynamic game process with the strategies of the three stakeholders tending to interweave and restrict each other. When the government promotes the construction of a CTS, it needs to promote the enthusiasm of schools and meet the needs of learners at the same time. Schools must strike a balance between resource investment and economic benefits and cooperate with the implementation of government policies. By selecting the appropriate courses and certification services, learners can push the schools and government to continuously optimize the CTS. This interactive relationship determines the adjustment of strategies of all stakeholders and the continuous improvement of the CTS. A systematic analysis of the evolutionary game path and stability strategy of the three stakeholders is of great theoretical significance to resolve the conflicts of benefit allocation among the three stakeholders and promote the stable and sustainable development of the CTS.

3.2 | Cost-Benefit Situation Among Stakeholders

The purpose of CTS construction is to serve learners, who are the primary beneficiaries. The benefits to learners include both economic and non-economic incomes; while the economic income is usually higher wages, and the non-economic returns generally manifest as improved education backgrounds, abilities, and related social status. It is worth noting that in the case of credential-oriented learning participation, learners tend to focus on obtaining certificates quickly and ignore in-depth understanding of the learning content. Learning becomes utilitarian and short-sighted under such conditions, which limits the deep improvement of ability. A CTS provides flexible learning opportunities and a variety of courses, enabling learners to choose the right learning path according to their benefits and demands, so learning participation oriented toward skill upgradations can further improve the learners' ability to enhance practical application and career competitiveness. In the most ideal condition, learners achieve the double return of certification and ability. More importantly, due to improvements in academic certifications and abilities, economic benefits such as wages will increase, and non-economic benefits, such as personal development opportunities and social status, will also improve. However, for all these benefits to accrue, learners must realize that they have to invest both some

time and cost (in the form of tuition fees) and participate in CTS learning.

To ensure that learners' learning outcomes are accurately entered into the CTS in a timely manner and that they receive appropriate certification, schools need to bear the construction and maintenance costs of the branch and related teaching costs, including the required investment in facilities, equipment, and human resources, as well as management and time costs. In the short term, if the courses and learning outcomes of learners can be certified by the CTS, the attractiveness of school curricula will be enhanced, resulting in more learners enrolling in the CTS, which will directly contribute to an increase in the tuition income of schools. In the long run, by integrating educational resources inside and outside schools, it can reduce the marginal cost of operating the CTS and promote the improvement of teaching quality and the professional level of teachers so as to achieve the goal of recruiting more learners. At the same time, schools will have the opportunity to enhance their social responsibility and reputation. Although the incomes of schools are almost entirely targeted at profit, it requires considerable funds to operationalize and maintain the CTS. Nevertheless, the return on investment through improvements in social reputation is likely to result in recruiting more learners and economies of scale, justifying the additional investment by schools.

In the early stages of CTS construction, the government supported relevant schools and learners by providing funds in an arrangement whereby schools undertook construction tasks and learners received tuition subsidies to participate in learning under the CTS. However, the government also needs to weigh the opportunity cost of reduced investment in other projects. As for the benefits to the government, in the short term, it can satisfy individuals' demands for skill and academic qualifications. In the long run, by promoting the construction of the CTS, the government is committed to improving the skills of the whole society, which, in addition to meeting the demand for improved skills in industrial development also promotes the construction of a lifelong learning system and a learning society. On the whole, the long-term benefits of promoting CTS not only include enhancing the quality of individuals but also providing multiple advantages to schools, enterprises, the government, and society.

4 Constructing the Game Framework in CTS

Evolutionary game theory provides a powerful tool for understanding strategy and behavior patterns in complex systems through mathematical models and

computer simulations (Lewontin, 1961; Samuelson, 2002). This theory is often used in the social sciences to explain social rules, cultural evolution, cooperation, and conflict. Based on the aforementioned interest relationship among stakeholders in the construction of a CTS, this section uses evolutionary game method to describe, deduce, and explain its operating mechanism and evolution pattern.

Before building an evolutionary game model, we should make reasonable assumptions about the game situation, which has a direct impact on the accuracy and effectiveness of the model. The hypothesis should include external constraints, strategy, as well as costs and benefits, through which the theoretical model can be transformed into a suitable mathematical model. Therefore, this section constructs the basic framework of the tripartite evolutionary game between learners, schools, and the government. Different from the "complete rationality" hypothesis in traditional game theory, these game players in evolutionary game theory exhibit "limited rationality" under incomplete information game due to the complexity of content and scenario.

4.1 | External Constraints of the Game

On the basis of the analysis of interest relationship, this paper selects learners, schools, and the government to form the game framework. All players play the game under the condition of incomplete information, aiming to maximize their own benefits, and all of them are risk neutral; that is, when facing uncertainty, players only care about expected returns but do not care about the size of risks.

To simplify the game analysis, this paper proposes six binding hypotheses:

Hypothesis 1: The game in CTS only involves learners, schools, and the government and is not affected by other subjects such as enterprises, employers, and educational cooperative institution.

Hypothesis 2: As an important supplement to normal education, CTS provides flexible learning paths and diversified learning resources. Therefore, in the game, we assume that all schools and all learners have equal and sufficient time to invest in the CTS.

Hypothesis 3: Each player has sufficient resources to participate in all forms of game payments and will not abandon the optimal strategy due to economic constraints or other internal reasons.

Hypothesis 4: The management and operation mechanism of the CTS is transparent, and all relevant information is open to all stakeholders to ensure their right to know the decision-making process.

Hypothesis 5: From the perspective of learners, when schools choose to implement the "active participation" strategy of constructing high-quality teaching

resources, the benefits of the “strong participation” strategy of learners choosing to study seriously are greater than the “weak participation” strategy of coping with learning.

Hypothesis 6: In terms of the school strategy, when the government chooses the “strong dominance” strategy of active supervision and support, the benefits of the “active participation” strategy of building high-quality teaching resources are greater than the benefits of the “negative response” strategy of providing low-quality teaching resources.

4.2 | Strategy Hypothesis of the Game

Based on the basic assumption of the stakeholder costs and benefits in the CTS, when stakeholders participate in the construction of the CTS, learners have the preference of “improving academic qualifications” and “improving ability”; the government has the preference of “providing educational opportunities” and “building a learning society with lifelong learning”; and schools have the preference of “tuition income” and “improving reputation.” It is further concretized into the hypothesis that all learners, schools, and the government have corresponding interest preference in their optimal strategy.

4.2.1 Learner Strategy

Achievement goal theory is a psychological theory used to understand and explain individuals’ motivations and behaviors in academic certificate and achievement. It holds that learners have two preferences in learning, including learning orientation and achievement orientation (Heyman & Dweck, 1992). Learners who tend to be learning oriented take acquiring knowledge as their main purpose. Such learners usually actively participate in courses and learning activities and seek deep understanding and knowledge application, which can be called the “strong participation” strategy to improve ability. The tuition fees for continuing education in China are relatively low, and the government subsidies can basically cover these costs. For instance, the Shanghai CTS has stipulated that the total tuition for the three-year undergraduate program starting from 2024 will be 9,600 CNY. Individuals who obtain academic or skill certificates through further education can enjoy a tax deduction of 4,800 CNY per year in China. For example, Shanghai provides 100% subsidies for workers to participate in employment skills training, and workers who obtain professional certificates will be entitled to additional subsidies. The combination of various subsidies can largely cover the tuition expenses during the learning process. Naturally, these subsidies are only available after learners successfully obtain certification, so those with an achievement orientation take earning credits and obtaining academic certificate

as their main goal. These groups usually choose easy courses and projects to obtain high scores and credits with lower learning effort, ignoring the actual course details in the learning process; so, these groups are called the “weak participation” strategy to obtain academic qualifications. In this paper, learners in the CTS hold the “strong participation (P)” strategy with probability p and the “weak participation (Q)” strategy with probability $1 - p$.

4.2.2 School Strategy

Construction of the CTS in China was initially proposed by government departments, with the NOU and its branches undertaking the task of construction. Under this model, schools either follow an “active participation” strategy to build quality teaching resources or a “passive participation” strategy to simply cope by providing low-quality teaching resources. Schools that adopt the “active participation” strategy will actively promote cross-school cooperation with resources sharing and co-construction, resulting in a higher cost of construction. At the same time, the CTS is used to promote knowledge dissemination and academic innovation, with the goal of improving the overall academic reputation of such schools. The goal of schools adopting the “passive participation” strategy is to meet the requirements of the government, avoid being punished for noncompliance by the government, and increase tuition income by attracting learners so as to improve the overall economic income without investing much in teaching resources construction. This study assumes that schools hold the “active participation (R)” strategy with probability q and the “passive participation (S)” strategy with probability $1 - q$.

4.2.3 Government Strategy

For the purpose of public service, the government provides educational opportunity and products for all sections of the population, and it has a great responsibility in the construction of a CTS. However, due to the differences in strategic orientation and ability, there will be a difference between “strong dominance” and “weak dominance” with continuous investment and supervision. This paper defines the “strong dominance” strategy as strong policy support and investment in the construction of the CTS by the government, including regularly reviewing and evaluating the operation of the CTS and ensuring the fairness and transparency of credit exchange and management processes. The “weak dominance” strategy means that the government has a relatively minor supportive role and invests relatively limited resources, which is mainly reflected in

insufficient supervision by the government for the participation of relevant stakeholders. Limited participation by the government may lead to lower market acceptability of the credit value when learners transfer credits. This will affect the long-term development of the CTS and the enthusiasm of participation in the process of building a lifelong learning system. This paper assumes that the government adopts a “strong dominance (U)” strategy with probability r and a “weak dominance (V)” strategy with probability $1 - r$.

4.3 | Payment Hypothesis of the Game

Suppose that learners’ costs are divided into fixed costs and variable costs. Fixed costs refer to expenses such as tuition fees that all learners must pay, while variable costs refer to the additional time and effort that learners who choose a “strong participation” strategy need to invest, which is consistent with their preference of goal orientation. Learners’ benefit consists of knowledge and credit. Knowledge benefit is a long-term benefit, which can be obtained only when the “strong participation” strategy of learners and the “active participation” strategy of schools are established at the same time because it is only under this strategy that learners can acquire more knowledge and gain an in-depth understanding. Credit benefit includes short-term income and long-term value-added income. Short-term income can be obtained by all learners when teaching activities are conducted smoothly. Long-term value-added income require learners to choose the “strong participation” strategy, schools to choose the “active participation” strategy, and the government to choose the “strong dominance” strategy, that is, learners and schools work

together and the government provides strong support and supervision. The specific connotations, establishment conditions, and symbols of the variables are shown in [Table 1](#).

It is assumed that the costs incurred by schools consist of two parts: fixed investment in the initial stage and the variable investment in the later stage. The initial fixed investment includes construction, human capital, facilities, and equipment costs. Variable investment is related to the strategy adopted by schools. Schools that choose an “active participation” strategy will incur higher variable investment, but this will also enable them to provide higher quality education and services, thus enhancing the reputation and social impact of such schools and thereby attracting more learners and partners. It is assumed that the income of schools consists of four parts, namely, tuition income, economies of scale income, reputation income, and social income. Among these, tuition income is the short-term income, while the other three are long-term incomes. Short-term tuition income will be maintained as long as teaching activities are performed smoothly. The realization of long-term benefits depends on the strategies adopted by the schools, learners, and the government. The establishment of economies of scale income, reputation income, and social income requires schools to choose an “active participation” strategy. In addition, reputation income requires learners to participate, while social income require learners to further choose “strong participation” strategy. Economies of scale income requires the government to adopt the “strong dominance” strategy of active supervision and support. The specific connotations, establishment conditions, and symbols of the variables are shown in [Table 2](#).

Suppose that the cost to the government is a

Table 1 Key payment assumptions relevant to learner strategy

Variable connotation	Establishment condition	Symbol
Tuition	Learners choose either strategy	C_{s1}
Learning time, effort, etc.	Learners choose “strong participation” strategy	C_{s2}
Knowledge income	Learners choose “strong participation” and schools choose “active participation” strategy	R_{s1}
Credit income	Schools and learners choose either strategy	R_{s2}
Certification income	Learners choose “strong participation” strategy, schools choose “active participation” strategy, and the government chooses “strong dominance” strategy	R_{s3}

Table 2 Key payment assumptions relevant to school strategy

Variable connotation	Establishment condition	Symbol
Teaching resources construction and other fixed costs	Schools choose either strategy	C_{t1}
Variable costs	Schools choose “active participation” strategy	C_{t2}
Tuition income	Schools and learners choose either strategy	R_{t1}
Reputation income	Schools choose “active participation” strategy and learners choose either strategy	R_{t2}
Scale economic income	Schools choose “active participation” strategy and the government chooses “strong dominance” strategy	R_{t3}
Social income	Schools choose “active participation” strategy and learners choose “strong participation” strategy	R_{t4}

measurable financial investment with different level. When the government chooses to participate in the management of a CTS, the general financial investment is usually always needed. If “strong dominance” strategy is chosen, the government also needs to invest additional financial funds for supervision and management. At the same time, the income of the government is also an estimated economic income and social welfare improvement. To improve the overall quality of life-long learning, enhance the ability of innovation, and inject impetus into the economic development of the country, a “strong participation” strategy by learners, an “active participation” strategy by schools, and a “strong dominance” strategy by the government need to be established simultaneously. The specific connotations, establishment conditions, and symbols of the variables are shown in Table 3.

5 Numerical Simulation Analysis of Different Benefit Demands

To more intuitively and deeply explore the dynamic adjustment of the participation strategies of learners, schools, and the government in CTS, this paper uses the MATLAB software to conduct numerical simulation. As initial conditions have a key role in the nonlinear dynamic systems, different initial conditions may significantly affect the evolution path of the system. The solving process of the evolutionary game is shown in the electronic supplementary material. To fully explain the stability of the evolutionary path under each condition, three sets of parameters were randomly started from different initial strategy combinations and evolved 100 times with time t . This practice follows the standard methodology of evolutionary game modeling and nonlinear dynamic simulation, where hypothetical yet reasonable parameter values are introduced to illustrate the potential trajectories of system evolution (Samuelson, 2002). As the exact empirical data for all variables are either unavailable or highly context-specific, the use of assumptions provides a controlled framework for testing the stability of equilibrium

strategies under varying initial conditions. The primary purpose of these assumptions is not to predetermine outcomes but to demonstrate the robustness of the model. By assigning different plausible values to costs, benefits, and payoffs of learners, schools, and the government, the model shows how stakeholder strategies converge toward a stable equilibrium regardless of initial fluctuations. As shown in the simulation results, regardless of whether the initial ratio is high or low, the evolution stability strategy of the stakeholders does not change.

For the equilibrium point (0,0,0), when $R_{l2} - C_{l2} < 0$, that is, when the variable cost of the schools is greater than the reputation income of the schools, (0,0,0) is the evolutionary stable point. To satisfy above conditions, we assume that $R_{s1} = 40$, $R_{s3} = 7$, $C_{s2} = 12$, $R_{l2} = 9$, $C_{l2} = 30$, $R_{l4} = 7$, $R_{l3} = 8$, $R_{g2} = 10$, $C_{g2} = 8$, $C_{g3} = 7$, and $R_{g3} = 8$. As shown in Figure 1, with the progress of evolution, learners gradually choose “weak participation” strategy, school chooses “passive participation” strategy, and the government chooses “weak dominance” strategy. According to the eigenvalue of the Jacobian matrix and the standard criterion that all eigenvalues < 0 imply an evolutionarily stable point, it can be seen that when the school chooses the “passive participation” strategy and the government chooses the “weak dominance” strategy, the income of learners choosing the strategy of “strong participation” is always smaller than that of “weak participation”. When learners choose “weak participation” strategy, schools choose “passive participation” strategy, and the government chooses “strong dominance” strategy, the income are always smaller than that of “weak dominance” strategy. Furthermore, when $R_{l2} - C_{l2} < 0$, the additional cost of “active participation” strategy is higher than the additional reputation income brought by the improvement of teaching resources. To control costs, schools tend to operate stably and maintain the existing teaching resources, and their decision-making will correspondingly turn to “passive participation.” This indicates that a positive cycle in the system is difficult to realize, while a negative cycle makes each participant tend to reduce their effort and cost.

Table 3 Key payment assumptions relevant to government strategy

Variable connotation	Establishment condition	Symbol
General financial invest	Government chooses either strategy	C_{g1}
Additional financial invest	Government chooses “strong dominance” strategy	C_{g2}
Repetitive construction cost	Learners choose “strong participation”, schools choose “active participation” and government chooses “weak dominance”	C_{g3}
Social welfare improvement	Learners, schools and government choose either strategy	R_{g1}
Economic income form increased education quality	Government chooses “strong dominance” strategy and schools choose “active participation” strategy	R_{g2}
Innovation income	Government chooses “strong dominance”, schools choose “active participation” and learners choose “strong participation” strategy	R_{g3}

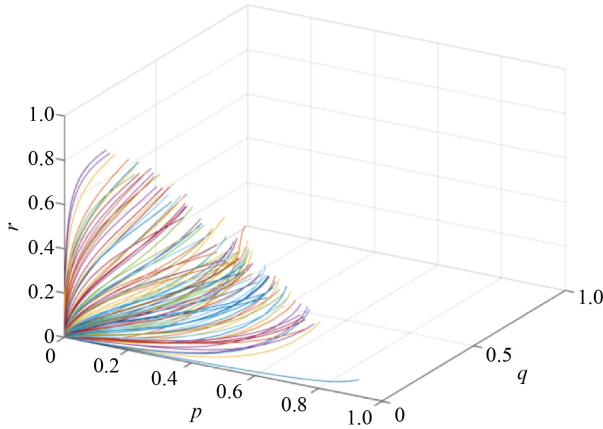


Figure 1 Evolution path of equilibrium point (0,0,0). r is the probability of government adopts a “strong dominance” strategy; p is the probability of the learners in the CTS hold the “strong participation” strategy; q is the probability of the schools hold the “active participation” strategy.

In the construction of a CTS, the interaction and influence among learners, schools, and the government form a complex dynamic equilibrium. When participants find that they cannot achieve significant income improvement even with their own efforts, they may choose to reduce investment to avoid unnecessary cost and effort. This rational self-benefit behavior can lead to a decline in the performance of the CTS because each stakeholder makes optimal decisions based on the current perceived environment, but these aggregated decisions may not be conducive to the positive development of the system. For example, if the schools believe that no matter how hard they try, improvements in the quality of education will not lead to a corresponding increase in reputation and tuition, then it may choose to maintain the preference of “passive participation.” Similarly, learners may choose the strategy of “weak participation” if they feel that no matter how hard they try, their academic certificate and ability will not be significantly improved because of the “passive participation” by schools. If the government believes that the cost of promoting education reform and strengthening CTS management outweighs the potential benefits, or if they have other priorities, they may choose the strategy of “weak dominance.” In this case, the system will eventually converge to (0,0,0), and its corresponding strategy combination is weak participation, passive participation, and weak dominance.

The equilibrium point (1,1,0) is an evolutionarily stable point, when these conditions of $C_{s2} - R_{s1} < 0$, $C_{l2} - R_{l2} < 0$, and $R_{g2} - C_{g2} + C_{g3} + R_{g3} < 0$ are satisfied. To satisfy the above conditions, we assume that $R_{s1} = 40$, $R_{s3} = 7$, $C_{s2} = 12$, $R_{l2} = 30$, $C_{l2} = 9$, $R_{l4} = 7$, $R_{l3} = 8$, $R_{g2} = 10$, $C_{g2} = 40$, $C_{g3} = 7$, and $R_{g3} = 8$. As shown in Figure 2, learners choose “strong

participation” strategy, schools choose “active participation” strategy, and the government chooses “weak dominance” strategy because, according to Hypothesis 5, when the schools choose “active participation” strategy, the income of the learners choosing the “strong participation” strategy is greater than that of the “weak participation” strategy. In the case of $C_{l2} - R_{l2} < 0$, that is, the additional cost incurred by schools adopting an “active participation” strategy is less than the extra reputational income brought about by the improvement in educational quality. The schools tend to encourage teachers and learners to participate in innovative practices, which helps the schools establish a good reputation in the education market, attracting more learners, thereby forming a virtuous cycle. Further, under the condition of $R_{g2} - C_{g2} + C_{g3} + R_{g3} < 0$, the total income of improving education quality and promoting economic development brought by the “strong dominance” strategy of the government cannot offset the additional financial cost. Therefore, the probability of the government choosing “strong dominance” strategy continues to decline. At this time, the system will eventually converge to (1,1,0), and its corresponding strategy combination is strong participation, active participation, and weak dominance.

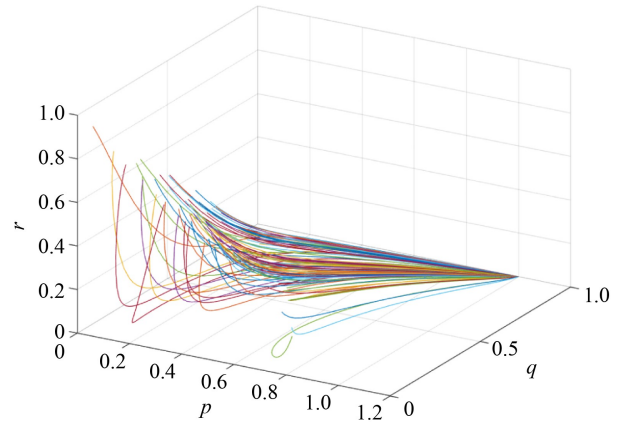


Figure 2 Evolution path of equilibrium point (1,1,0). r is the probability of government adopts a “strong dominance” strategy; p is the probability of the learners in the CTS hold the “strong participation” strategy; q is the probability of the schools hold the “active participation” strategy.

In this case, the “strong participation” strategy of learners promotes the “active participation” of the schools, because the high level of learners’ participation brings more positive incentive, which further promotes the curriculum optimization of the schools. At the same time, the schools have enhanced its market competitiveness and social reputation through continuous improvement in the quality of education, thus forming a virtuous circle. Attracting more learners and promoting the continuous development of the schools, the

schools further increase its income through economies of scale, thus forming a stable equilibrium state (1,1,0). The financial constraint of the government was prompted it to choose a “weak dominance” strategy with weak supervision and support for constructing the CTS, aiming to reduce the financial pressure. However, the “weak dominance” strategy leads to lower education quality of schools and subsequent low participation rate of learners, in which the increase in economies of scales of the schools are not enough to cover its cost of “active participation.” Thus, it shifts toward a strategy combination (0,0,0) in which all stakeholders do not participate.

The equilibrium point (1,1,1) is an evolutionary stable point, when $C_{s2} - R_{s1} - R_{s3} < 0$, $C_{l2} - R_{l2} - R_{l3} - R_{l4} < 0$, and $C_{g2} - R_{g2} - C_{g3} - R_{g3} < 0$. To satisfy the above conditions, we assume that $C_{s2} - R_{s1} - R_{s3} < 0$, $C_{l2} - R_{l2} - R_{l3} - R_{l4} < 0$, and $C_{g2} - R_{g2} - C_{g3} - R_{g3} < 0$. As shown in Figure 3, learners choose “strong participation” strategy, schools choose “active participation” strategy, and the government chooses “strong dominance” strategy because, according to Hypothesis 5, when the schools choose “active participation” strategy, the income of the learners choosing the “strong participation” strategy is greater than that of the “weak participation” strategy. According to Hypothesis 6, when the government chooses the strategy of “strong dominance,” the income of “active participation” strategy is higher than that of “passive participation” strategy. In the case of $C_{g2} - R_{g2} - C_{g3} - R_{g3} < 0$, the total income of improving education quality and promoting social innovation brought about by the “strong dominance” of the government will be higher than the additional financial cost. Therefore, the government tends to promote the construction of the CTS, and the

probability of “strong dominance” strategy continues to increase. In this case, the system will eventually converge to (1,1,1), and its corresponding strategy combination is strong participation, active participation, and strong dominance.

In fact, the “strong dominance” strategy of the government has effectively promoted the construction of the CTS through system support. Strong supervision and financial investment can significantly improve the quality of education and promote economic development. At this time, the strong dominance of the government can effectively promote the active participation of schools and improve the quality of education and social innovation ability so as to attract more learners, forming a positive cycle. In contrast, if the government chooses “weak dominance,” it may lead to low quality of educational resources, which will reduce the enthusiasm of schools and learners to participate, thus forming a negative cycle. Therefore, the advantages of the “strong dominance” strategy have become more obvious, and the government has been encouraged to take more active intervention to achieve the long-term development of the CTS and the stability of the equilibrium point (1,1,1).

In short, the system has three stable states, including (0,0,0), (1,1,0), and (1,1,1). In the case of (0,0,0), learners, schools, and the government all practice passive participation in decision-making, learners lack the motivation for active learning, schools do not intend to actively improve teaching quality, and the government does not take effective support and supervision, which ultimately makes the CTS useless. The expected income of the three stakeholders cannot reach the ideal state. In the (1,1,0) state, learners choose “strong participation” and schools choose “active participation,” making the construction of a CTS seemingly run smoothly, but the preference for “weak dominance” strategy by the government limits the long-term operation of the CTS. “Weak dominance” strategy leads the CTS to lack continuity and stability. In the long run, the “weak dominance” strategy of the government will lead to schools facing uncertainty in improving teaching resources, resulting in a shift to the strategy of “passive participation.” Meanwhile, learners, in the process of pursuing knowledge and certificate, may be affected by the instability of the CTS. These finally shift toward the positive (0,0,0) state. Therefore, the dynamic optimal combination of learners, schools and the government in the tripartite game is (1,1,1), that is, learners choose “strong participation” strategy, schools choose “active participation” strategy, and the government chooses “strong dominance” strategy. In this state, the joint action of all stakeholders will produce significant positive effects. In others words, driven by the “strong participation” strategy, learners will participate more actively in learning through the CTS and choose

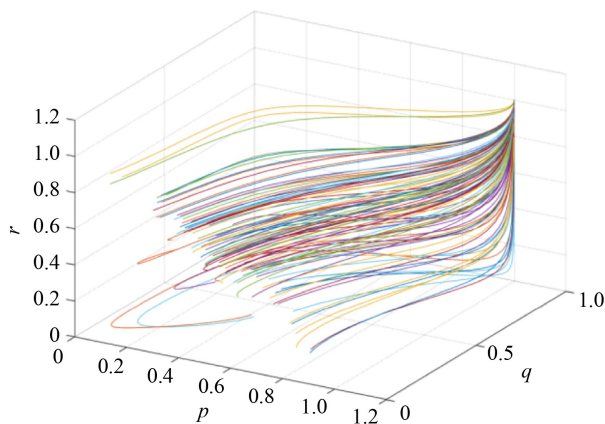


Figure 3 Evolutionary path of equilibrium point (1,1,1). *r* is the probability of government adopts a “strong dominance” strategy; *p* is the probability of the learners in the CTS hold the “strong participation” strategy; *q* is the probability of the schools hold the “active participation” strategy.

suitable learning paths and resources. Under the strategy of “active participation,” schools will continue to explore and implement new teaching methods and curriculum and use the CTS to provide more diversified learning opportunities and selection for learners. In the case of “strong dominance” strategy, the government ensures the smooth construction of the CTS through policy guidance, capital investment, and improvements in supervision. The strong support of the government can not only provide the skill level but also attract the enthusiasm of learners to participate in the learning of CTS through effective supervision and certification, which is conducive to the construction of a learning society. This stable state not only maximizes the income of all stakeholders through their active interaction and cooperation but also completes the mission of smooth lifelong learning.

6 Conclusions and Policy Implications

6.1 | Conclusions

Based on the cost-benefit relationship of each stakeholder in the process of constructing a CTS, we build in this paper a dynamic evolutionary game model around learners, schools, and the government from external constraints of the game, strategy hypothesis, and payment hypothesis, and, using MATLAB, simulate the numerical parameter to reveal the evolution process of each stakeholder under different strategy combinations. This study finds that learners have the interest demand of improving academic qualifications and ability, the government has the interest demand of providing educational opportunities and building a lifelong learning system, and schools have the interest demand of tuition earnings and improving reputation when all stakeholders positively participate in the construction of a CTS. The strategy combination (1,1,1) of “strong participation” of learners by ability improvement, “active participation” of schools by constructing high-quality teaching resources, and “strong dominance” from the government by continuous capital support and supervision is the optimal strategy to maximize the welfare of all stakeholders. This optimal equilibrium is fundamentally aligned with the goals of modern digital education, which emphasizes accessibility, personalization, and the seamless portability of learning data.

6.2 | Policy Implications

6.2.1 Establish a Cost-Benefit Sharing Mechanism for the Stable Operation of the CTS

The cost-benefit analysis shows that the stable status of the CTS is the result of active participation of all

stakeholders. Learners gain skills and academic qualifications in this system and further promote economic development. Therefore, the government and learners should be the main cost-sharers of the CTS. To reduce the financial burden of learners and increase their willingness to participate in learning, there is a need to establish a financial system in which the government, learners, and schools build and operate the CTS together as soon as possible. This should include investments specifically targeted at developing and maintaining the necessary digital education platforms and data security systems that underpin the CTS.

6.2.2 Build a Lifelong Learning System with CTS as the Carrier

The government and schools actively participate in the construction of a CTS, which can attract learners to actively participate in learning through the CTS. Therefore, leveraging the tools of digital education, a national unified learning achievement certification, storage, accumulation, and transfer system should be established. This involves creating interoperable digital learning records and promoting the development of high-quality online and blended learning resources to attract learners’ active participation in learning through high-quality educational resources and smooth channels for skill growth, thus building a lifelong learning system for all people.

6.2.3 Construct the Unified Supervision and Evaluation Standards for the CTS

The key to the active participation of stakeholders in the construction of CTS lies in the effective supervision and evaluation to meet the learning demands of learners and enhancing the promotion and use value of teaching resource construction by schools. Therefore, under the guidance of the government, it is necessary to build a national unified supervision and evaluation standards and thus reduce the cost of repeated construction and learning. These standards must be “digital-first,” designed for interoperability between different educational technologies and platforms, ensuring trust and efficiency in a digitally-mediated system. At the same time, there is also a need to further optimize the supervision and evaluation standards of the CTS so as to achieve the goal of lifelong learning.

7 Limitations and Future Research

Although this study contributes to the literature by constructing a tripartite evolutionary game model of CTS involving learners, schools, and the government,

several limitations must be acknowledged. The model only considers three primary stakeholders, that is learners, schools, and the government, while other critical actors such as employers, industry associations, private training institutions, and international education providers are excluded. In practice, the participation of these entities is vital to the successful construction and operation of a comprehensive CTS, particularly in terms of aligning educational outcomes with labor market needs and ensuring cross-sector recognition of credits. In addition, some important variables are not captured in the current framework. For instance, regional economic disparities, differences in local education financing mechanisms, and the heterogeneous objectives of different school types (e.g., research universities, vocational colleges, and open universities) are not modeled. These contextual factors could significantly influence the cost-benefit calculations of the stakeholders and strategic choices in practice.

Future research could extend the model in several directions. Empirically, survey data and case studies could be incorporated to parameterize the game model more accurately and test its predictions under diverse conditions. Theoretically, the inclusion of additional stakeholders and context-specific variables would improve the explanatory power of the model and external validity. Moreover, cross-country comparative studies, particularly with developing economies facing similar challenges of scale and educational stratification, could further enrich the understanding of CTS construction dynamics.

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Conflict of Interest The authors declare that they have no conflict of interest.

Data Availability Statements The authors confirm that all data generated or analysed during this study are included in this published article.

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References

- Agelasto, M. (2010). Educational transfer of sorts: The American credit system with Chinese characteristics. *Comparative Education*, 32(1), 69–94.
- Almeida, R. K., Amaral, N. L., & De Felicio, F. (2015). *Assessing advances and challenges in technical education in Brazil (English)*. Washington: World Bank Group.
- Cha, H., Kotabe, M., & Wu, J. (2023). Reshaping internationalization strategy and control for global e-commerce and digital transactions: A Hayekian perspective. *Management International Review*, 63(1), 161–192.
- Choudhary, A., Chawla, M., & Tiwari, N. (2024). A blockchain-based framework for Academic Bank of Credit with transparent credit mobility. *Cluster Computing*, 27(5), 6667–6688.
- Corrales-Herrero, H., & Rodríguez-Prado, B. (2024). Mapping the occupations of recent graduates. The role of academic background in the digital era. *Research in Higher Education*, 65(8), 1853–1882.
- Donaldson, T., & Preston, L. E. (1995). The stakeholder theory of the corporation: Concepts, evidence, and implications. *The Academy of Management Review*, 20(1), 65–91.
- Edwards, R. (2004). International perspectives on lifelong learning: From recurrent education to the knowledge society. *International Journal of Educational Development*, 24(3), 334–336.
- Friebel, H. (2014). Educational biographies in Germany: From secondary school general education to lifelong learning. *Australian Journal of Adult Learning*, 54(2), 121–144.
- Heyman, G. D., & Dweck, C. S. (1992). Achievement goals and intrinsic motivation: Their relation and their role in adaptive motivation. *Motivation and Emotion*, 16(3), 231–247.
- Hotta, T. (2014). International collaboration through a permeable framework for credit transfer: The potential application of Asian academic credits (AACs). *Comparative Education*, 2014(48), 93–103.
- Hotta, T. (2020). The development of “Asian academic credits” as an aligned credit transfer system in Asian higher education. *Journal of Studies in International Education*, 24(2), 167–189.
- Jia, C. Y., & Im, M. (2023). Analysis of education needs for instructional competency of lifelong education instructor in China. *The Journal of Asian Studies*, 26(2), 87–99.
- Jiangsu Open University, & Jiangsu CTS Center. (2023). *Investigation Report on the Progress of the Construction of China CTS 2020*. Nanjing: Phoenix Education Publishing. (in Chinese).
- Karran, T. (2005). Pan-European grading scales: Lessons from national systems and the ECTS. *Higher Education in Europe*, 30(1), 5–22.
- Kim, J., & Park, C. Y. (2020). Education, skill training, and lifelong learning in the era of technological revolution: A review. *Asian-Pacific Economic Literature*, 34(2), 3–19.
- Kruss, G., McGrath, S., Petersen, I. H., & Gastrow, M. (2015). Higher education and economic development: The importance of building technological capabilities. *International Journal of Educational Development*, 43, 22–31.
- Lewontin, R. C. (1961). Evolution and the theory of games.

- Journal of Theoretical Biology*, 1(3), 382–403.
- Mason, T. C., Arnove, R. F., & Sutton, M. (2001). Credits, curriculum, and control in higher education: Cross-national perspectives. *Higher Education*, 42(1), 107–137.
- Mendoza-Chan, J., & Pee, L. G. (2024). Digital skilling of working adults: A systematic review. *Computers & Education*, 218, 105076.
- Merritt, J. (2008). Lifelong learning and the academy: The changing nature of continuing education (review). *The Review of Higher Education*, 31(3), 369–370.
- Park, H., Choi, J., Kim, J. H., & Hwang, J. (2019). The Academic Credit Bank System in the Republic of Korea: An effective medium for lifelong learning in higher education. *International Review of Education*, 65(6), 975–990.
- Perulli, E. (2015). Recognising non-formal and informal learning: An open challenge. *The Quality of Higher Education*, 6, 94–116.
- Polidano, C., van de Ven, J., & Voitchovsky, S. (2021). Are broad-based vouchers an effective way to support life-long learning. Evidence from an Australian reform. *Research in Higher Education*, 62(7), 998–1038.
- Ryan, C., Bergin, M., Titze, S., Ruf, W., Kunz, S., & Wells, J. S. G. (2018). ECVET and ECTS credit equivalency in higher education—A bridge too far. *European Journal of Education*, 53(4), 600–610.
- Samuelson, L. (2002). Evolution and game theory. *Journal of Economic Perspectives*, 16(2), 47–66.
- Souto-Iglesias, A., & Baeza_Romero, M. T. (2018). A probabilistic approach to student workload: Empirical distributions and ECTS. *Higher Education*, 76(6), 1007–1025.
- Suryadi, A., Budimansyah, D., Solehuddin, M., Shantini, Y., & Yunus, D. (2020). Microcredit provision, lifelong learning, and productivity of poor women in Indonesian villages. *Adult Education Quarterly*, 70(4), 360–376.
- Teichler, U. (2003). Mutual recognition and credit transfer in Europe: Experiences and problems. *Journal of Studies in International Education*, 7(4), 312–341.
- Toyne, P. (1979). *Educational credit transfer: Feasibility study*. London: Department of Education and Science.
- Zhou, M. X. (2019). Credit: Self-growth, dreaming of the future—Exploration and practice of Zhejiang lifelong education credit bank. *Open Access Library Journal*, 6(4), e5366.