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THE SOCIAL MEANING OF FOLK BELIEF AND THE CONSTRUCTION OF ITS SACRED RELATIONSHIP--A STUDY OF THE BELIEF RELATIONSHIP BASED ON "XIADI ANCIENT VILLAGE" IN THE EASTERN GUANGDONG

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Abstract: Xiadi located in the eastern Guangdong province is a simplex clan ancient village with a history of over 700 years. There are four Huang's ancestral halls, one Xuan Tian Ancient Temple (folk belief), one Buddhist Lodge and other places of worship in this village. The present situation of multiple beliefs in this village and the simplex clan relationship provide a great example for discussing the social meaning of folk beliefs and its construction of sacred relations. Distinguished from the emphasis of Max Weber, C.K.Yang and other scholars on the institution of Chinese religious belief, such as its faith-based organizations and meaning system, this paper will exam the social meaing of folk belief, which seems to be full of worldly and utilitarian colors but also involves the fundamental problem of its sanctity, with the understanding of Durkheim's religious belief and the concept of Li Xianping's "Relationship-Belief" model.
Keywords: Folk belief; Xuan Tian God; Social meaning; Sacred relationship

1 INTRODUCTION

On the study of Chinese folk belief and its local social relations, there are many classical discussions such as "Diffused and Institutional religion" in Sociology of Religion [1], and different perspectives on "North China Model" and "South China Model" [2] by Chinese anthropologist. From macroscopic to microscopic, these studies have different methods and emphasis on the rituals, organization and other contents of Chinese folk belief on the basis of rich experience observation and unique explanatory understanding. However, in the discussion of belief relationship or social relations, they seem to have a similar conclusion by the case observation of different regions. In the old days, the collective ritual to the Gods [3], which hold in Yanzhou Island, eastern Guangdong Huizhou, was able to integrate several villages around the temple into a collective of faith. Nowadays, the rapid change of social order, which happens in Qingheng village, Hebei Jinjing, is promoting the reconstruction of those collective rituals [4].

It is obvious that the rituals of chinese folk belief are facing rapid changes both in north and south China, and it is easy to associate it with the changes of social order. Those universal ritual changes, then, make us wonder why most rituals of folk beliefs are so easy to change over times or events, while institutional religions keep its ritual traditions strictly according to its old doctrines? Do the ritual changes on the surface mean a new change in its inside of faith? In the process of changes, what is living in the center of folk belief? Will the vague limits of folk belief to the divine and the secular be obvious, or more entangled? Does the emergence of a new ritual mean the construction of a new "sacred relationship"[5]? Is social order a constraint, a motivator, or a fundamental power to Chinese folk belief?

In order to understanding the meaning of social order to the construction of the sacred relationship in folk beliefs, it may need a large number of field researches, classic case studies of folk belief, and even exchanges and cooperation in different disciplines. And it is also best to base itself on the present, realistic and practical materials, rather than on the unified theory of premature assumptions, so that the "rituals of the folk belief are attributed to the realm of faith, and its order is attributed to the social sphere", making them only seem close to each other. In the problem of the construction of sacred relationship, from the social practice of folk belief, the practical logic of each temple should be an important angle to examine the social foundation of folk belief, the self-construction of folk belief in the changing social environment and so on. Therefore, this paper will try to take an ancient village called "Xiadi" in eastern Guangdong province as an example, through combing the social relations between villages and temples, to explore the connection between the social meaning of folk belief and its construction of sacred relationship.

2 FOLK BELIEFS: A VASSAL OF CLAN CULTURE OR A FOOTNOTE OF INSTITUTIONAL RELIGION?

"Xiadi Ancient village" (hereinafter referred to as Xiadi) located in Guan Bu Town, Chaoyang District, Shantou, is a simplex clan village which have a long history of over 700 years. People lives here have a same family name "Huang". According to the local history book "Chaoyang Annals" published in the years of Qing Dynasty's Emperor Kuang Hsu, Huang Jingde is the Xiadi's first generation ancestor. His original hometown was Putian, Fujian. He moved to Xiadi in Song Dynasty and became the governor of Chengxiang county after a selection. He was not only kind but also good at handling government affairs. He was later transferred to Chaoyang county but did not take the office on the grounds of illness and finally settled in Xialin. [6] Huang's clan of Xialin was later divided into three (Tanghou, Pushang, Xiadi),

and Xiadi was established by Huang Jingde's fourth son Huang Dongchun. Since then, both in the genealogy of Xiadi and the inscription of ancestral hall, Huang Jingde was the first-generation ancestor of Xiadi and Huang Dongchun was the second.

Today, Xiadi is home to more than 8,500 people of Huang's clan, with a village area of about 3.27 square kilometers. There are four ancestral halls in the village, as well as one Buddhist Lodge, one Xuan Tian Ancient Temple, one Double-loyal Ancient Temple and other places of religious belief. Around these shrines, Xiadi villagers attend more than 20 related sacrificial activities each year (as shown in the table 1 below). Among these sacrificial activities, the worship ceremony for Huang's ancestor has the most unified organization as it is organized by the clan and it is also the most solemn one as its hosted by clan elders. Distinguished from this serious and unified ancestor worship ceremony, Chaoshan area's folk belief rituals are grand in scale and extremely colorful in form. There are "pig weight competition, racing goose, fighting drama, fighting canopies and other customs" from the past, and now as " the content of festive entertainment is added", folk belief rituals are becoming increasingly lively and extraordinary. [7] So compared with the serious and unified ancestor worship, is this kind of celebration of hustle and bustle is only the cultural vassal of local society (in Chaoshan, it is more about clan organization)? Are the operating organization and social structure only the "dual" (Faith Organization-Social Structure) mosaic relationship?

Table 1 Annual Timetable of Worshipping Activities in Xiadi[①]

No.	Time		Topic	Location
1	January	morning on the 1st	Worship the ancestors	at home
2		morning on the 2nd	Worship the ancestors	at home
3		4th	Welcome the Gods (back to earth from heaven)	Worship gods at home or outside
4		5th	Worship the Xuan Tian God	Xuan Tian Ancient Temple
5		9th	Birthday of Heaven and Earth Parents	Tian Gong worshipping site
6		dust on the 15th	Worship the ancestors on the Lantern Festival	at home
7		29th	Birthday of the Goddess Hua Gong Ma	at home
8	February	11st	Worship the seventh-generation ancestors	graveyard
9	March	3rd	Birthday of Xuan Tian God	Lord Palace
10		19th	Birthday of the Goddess Zhu sheng	A Niang
11		29th	Birthday of the local land god	Sites of the local land god
12	April	Noon of 4th、5th 、6th	Worship ancestors on the QingMing Festival	at home、tomb sweepings
13	May	Noon on the 5th	Worship the ancestors on the Dragon Boat Festival	at home
14		13rd	Birthday of Kuan-ti	Kuan-ti Temple
15	June	15th	Birthday of the Goddess Wu Gu	at home
16	July	7th	Worship the Goddess Hua Gong Ma	at home
17		14th	Worship Si Ming Gong	at home
18		noon on the 15th	Worship the ancestors on Hungry Ghost Festival	at home
19		29th	Worship gods	the squares of each district
20	August	evening on the 15th	Worship the ancestors in the midterm festival、Moon God	at home
22	October	15th	Birthday of the Goddess Wu Gu Mu	at home
23	December	morning on the 29th	Worship the ancestors on the winter solstice	at home
24		24th	Farewell to Gods (see of the Gods go to haven)	ancestral halls、at home

① Note: Dark color is for folk belief related activities and the rest are the ancestor worship activities. The time is according to Chinese traditional calendar.

25		29th/30th	Worship the ancestors on the New Year's Eve	at home

3 THE "BAI LAOGONG" AND "BAI LAOYE" CENTERED ON CLAN ORGANIZATION

People lives in Chaoshan district call their sacrifice tradition which worshipping their ancestors as "**Bai Laogong**". Based on the scale and form of villagers' participation, "Bai Laogong" custom in Xiadi can be classified into three categories: the first is the worship of close dead relatives which held separately in each family, the second is for each big branch house's ancestors, and the third is the worship of the first-generation ancestor Huang Jingde which held by the whole clan of Huang, and even the whole Xialin Huang's clan. The first family-based ancestor worship is the smallest, and the worship objects are usually dead family members within five generations. This is usually carried out in their own homes or cemeteries within the home unit. The second is to worship the ancestors of each branch. In Xiadi they are the descendants of Huang Wuwei (Huang Jingde's third son) worshipping him in the annual lunar calendar February 11 and the descendants of Huang Tingyu (Huang Jingde's fourth son) worshipping him in the annual Lunar New Year February 9. The third is the distant ancestors worship organized by the "**Association of the Elders**" (composed of the Huang's prestigious male elderly in the village) and involved by the representatives of Huang's clan. The object of worship is the earlier ancestors of Xiadi, the original ancestral, the second-generation ancestor, the sixth-generation ancestor. The number of villagers participating in the worship is usually about 50, mainly composed of the elderly over the age of 60 in Xiadi.

"Association of the Elders" in Xiadi is not only in charge of the co-ordination of "Bai Laogong" ceremony, but also responsible for presiding over the Xiadi's folk gods celebration named "Bai Laoye". These folk belief rituals are born out of the traditional religious beliefs, because of the large number of temples in Chaoshan area (according to the book "Chaoshan Temple", there are tens of thousands of various large or small temples, shrines, halls, palaces and more than 170 species Gods being worshped in Chaoshan area.) [8], institutional religion in the historical process of Chaoshan society gradually declined, or have never strictly controlled the local temples, so that these folk temple rituals become the collective activities of local villages to a greater extent. According to Huang Ting, in the sacrifice ceremony of the local village, the social sacrifice and the temple festival gradually fused, forming the tradition of "Bai Laoye" and "began to shoulder the society function of promoting the community unity and strengthening the rural governance"[9].

So, were the social festival and temple festivals in the villages of Chaoshan area clearly separated in the past, or they are the same subject's activities on different topics from the beginning? This issue requires a great deal of historical research, let us move on and put the focus on today's ritual activities to see whether the two sacrificial activities have been combined today, or to what extent, in which areas are still divided.

4 FOLK BELIEFS CENTERED ON "XUAN TIAN GOD TEMPLE"[10]

There are three relatively important folk beliefs festivals in Xiadi each year, "Shen Luotian" (welcome the Gods back to earth from heaven to guard the people) at the beginning of the year, "Farewell to Gods" (to thank the Gods' work and see them off to heaven to debrief to their boss) at the end of the year, as well as "The Birthday of Xuan Tian God" (which hold on the lunar March 3rd), the villagers will also worship local gods of the land and other gods in the 5th and15th day of each month in lunar calendar. Even on the sacrifice day of the Huang's family, these gods will enjoy incense at home at the same time. In addition, the ancient temple is also dedicated to the Mercy Goddess, Prince, Huang Yilong, Bagua Master, Prince (Wang Yu), Longwei Master, and so on, some villagers will also go to the ancient temple for those gods' birthday.

In Xiadi, the sacrificial activities of all kinds gods are centered on the "Xuan Tian God Temple" (commonly known as "Xuan Tian Ancient Temple" and "the Palace of the Lord"), and the celebration day for the birth of Xuan Tian God is the most spectacular one. On this day, the villagers who works out side will do their best to come back home for attending this celebration. The celebration also provides Huang's members a great opportunity to bond with their friends and relatives. XuanTian God (also known as Zhen Wu God) is been called "Big Master", or "Buddha" in Xiadi, even though he is more often seen as a god of Taoism. According to the inscription of "A Brief history of the temples in Xiadi ", Xuan Tian God Palace was founded in the Ming Dynasty (1456). Huang Yingjin of the Huang's sixth generation advocated the establishment of the temple after becoming an official in Taihe County, Jiangxi Province. Inside the Xuan Tian God Temple, Xuan Tian God is in the center, on the left is the Mercy Goddess, on the right is the Flower Goddess, and on the small pavilion was Prince as the god to keep the village safe. During the third year of K'ang-hsi emperor in the Qing Dynasty (1633), temples were destroyed because of war between the empire and pirates. In 1668 after war end, people restarted farming and got harvest in successive years. In 1678-1959, temple was reconstructed. In 1968, during the Cultural Revolution, the wood of the temple was demolished for reform tools and only the site was remained. After Chinese economic reform, in 1992, reconstruction was hosted by the Association of the Elders and it was completed in August 1993. The total area was 282 square meters, Temple Front Square covers an 490 sqm and cost more than 500,000 yuan.

Xuan Tian God temple is also the "light the Lantern" site. At the night of fifth to seventh day of Chinese lunar January, the villagers will in the unit of family take lanterns and incense to the ancient temple to worship. In general, the number of lanterns is decided by the number of males in each family, because the origin of the "light the Lantern" custom is closely related to the patriarchal society, and now it is more a ritual of praying for peace.

There is also a Double Loyalists Ancient Temple on the left of Xuan Tian God Temple. This temple is also managed by the Association of the Elders. It stands in the same place and have similar building style like Xuan Tian God Temple. But for the villagers, its importance is far less than the Xuan Tian God Temple. “Double loyalists “refers to two heroes in history called Zhang Xun and Xu Yuan. The story says that An Lushans’s rebel army attacked the strategic town Sui Yang in 757. At that time, Zhang Xun was the deputy general, and Xu Yuan was the governor of Suiyang. In the case of huge gap of strength and lack of supplies, they insisted on keeping the city and won 10 months ' precious time to conquer the rebellion. The story of these two loyalists is popular in Chaoshan and became the Gods in history. In the annual Chinese New Year celebration for Gods in village, these two loyalists also have their vital position in the Gods Parade. Chen Chunsheng believes that the widespread worship of the two loyalists in Chaoshan area and the growing influence of local clan organizations on local forces actually strengthen and complement each other. [11]

5 THE BUDDHIST LODGE HAVE A FOLK GOD, AND THE XUAN TIAN GOD TEMPLE HAVE THE LIGHT OF BUDDHA

In addition to Xuan Tian God Temple, Double Loyalists Ancient Temple of folk belief, there is another important place of institutional religious called Buddhist Lodge (Full name is “Shantou Chaoyang District Buddhist Lodge) in Xiadi. Folk beliefs such as the Xuan Tian God Temple, Double Loyalists Ancient Temple are managed by the Huang’s clan organization “Association of the Elders”, while Buddhist Lodge is managed by Buddhist believers. Usually we think the diffused religion and intuitional religion run in separately because they have different faith, however, in Xiadi those two kinds of religion linked to each other in a special way. In today's Buddhist Lodge, there is still a “Ancient Tree Goddess Temple” of folk belief. On the lintel of the Xuan Tian God Temple, there is a board saying, “The Light of Buddha Shines Forever”. Also, the Xuan Tian God is called Buddha in here. It seems that the folk belief temple derived from Taoism was no longer the vassal of Clan culture but became the footnote of institutional religion.

Buddhism was spread into Chaoshan from the Southern Dynasties (457-465) [12]. There are many Buddhist temples in Chaoshan and the Chaozhou Kaiyuan Temple, Chaoyang Lingshan Temple and Jieyang Twin Peaks Temple are rather famous. Near Xiadi, three Peaks Temple and Mozang Temple were built in the Song Dynasty, and Meifeng Temple, Jingshan Temple were built in the Ming Dynasty. Buddhism has a wide range of believers in Chaoshan, but until the 60 's, Xiadi had its first place to worship the Buddha named the Tranquil Heart House. In terms of rituals and the scale of activities, Xiadi Huang's worship activities around the folk gods and ancestors are very grand and colorful, especially “the Deities Parade” in Chinese New Year and “Wuwei Memorial Day “(one of Huang’s famous ancestor) are usually participated by the whole village. Some folk Gods are enshrined by every family such as the Flower Goddess, Kitchen Master and so on. In contrast, Buddhism is slightly silent in the village. There are no large-scale Buddhist activities in village, nor is it believed in the whole village. Then why did this small-scale faith affect the folk god, and the light of Buddha can shine on the most important Xuan Tian God Temple? The reason is closely related to the fact that Buddhist Lodge was the first to win the legalization from local government.

Buddhist Lodge's predecessor, the Tranquil Heart House, is the first free Buddhist worshipping place set up by a group of cousins for the fours towns (Guan Bu, Jin Yu, Zaopu, Xilu) around Xiadi, and it was founded by Huang Hongjin. In 1990, Huang Lilie served as the vice president and secretary general of Guangdong Buddhist Association. In order to give Huang Hongjin and local Buddha believers a legal place of faith, Huang Lilie applied to the Guangdong Provincial Religious bureau to set up a Buddhist Lodge. The Buddhist Lodge was built in 1995 and then became a cultural unit officially protected by Guan Bu local government. When the establishment of Buddhist Lodge, in order to respect the villagers' natural god belief, the “Ancient Tree Goddess Temple” is preserved, the Buddhist faith does not exclude the folk faith of the Ancient Tree Goddess.

In addition, believers of the Buddhist Lodge will even “do in Rome as Rome does” and attend the ceremony when Xiadi villagers celebrate the Deities Parade festival in Chinese New Year. Besides, on 7th July “Sending Incense Boat” day, Lantern Festival and 15th January some festival of folk beliefs, a few of believers from Buddhist Lodge will be invited to the Xuan Tian God Temple to chant. As mentioned earlier, Xuan Tian God here is regarded as a “Buddha” revered by the local believers of Buddhism.

Whether Xuan Tian God is a deity of Taoism or a Buddha of Buddhism maybe is serious academic problem, but in Xiadi it’s just a history result. It should be noted from the “Brief History of Xiadi temples”, during the Ming and Qing dynasties, Buddhism and Taoism those institutional religion in Chaoshan began to decline as they were impacted by folk belief gods incense. At that time, the Xuan Tian God and other folk belief gods were introduced to Xiadi by Huang’s clan, and the Xuan Tian God Temple was seen as as a folk belief temple at the beginning. The Mercy Goddess, the Flower Goddess and the Prince of the temple sacrifice are all popular folk gods in Chaoshan. After the temple was re-built in 1993, the temple was first time marked by the “The Light of Buddha Shines Forever”. In 1990, Xiadi Buddha Lodge was established, and it was completed in 1995 as a cultural unit protected by Guan Bu town. In 1992, Xuan Tian God Temple and Double Loyalists Ancient temple were reconstructed. In1993, Xuan Tian God Temple’s reconstruction was done. With the combination of time and relationship, it seems that folk temples inlaid “The Light of Buddha Shines Forever” is also a matter of water.

6 THE MIXED INCOME AND EXPENDITURE OF FOLK BELIEF AND ANCESTOR WORSHIP

In Xiadi, the Xuan Tian God is known as “Buddha”, the Mercy Goddess in this folk belief temple is the incarnation of

"Guanyin", on the other hand there is a folk god named Ancient Tree Goddess living in Buddhist Lodge. In the first month of every lunar year, the Association of the Elders in Xiadi will host the biggest celebration "the Deities Parade" in this village, and all the Xiadi villagers would be mobilized, even the believers of Buddhism would take part in. Theoretically, the clan, folk beliefs and Buddhism obviously have distinguished existing and acting forms, but in Xiadi they interact with each other in rituals and culture. Behind this religious harmonization is the co-ordination of the Association of the Elders in Xiadi, a kind of secular social power. Ancestor worship, institutional religion and folk belief accept each other, while the power of clan dominates and accommodates all forms of belief. When it comes to the incense money management of sacrifice of ancestors and gods, this kind of fusion and relation is more prominent.

Xuan Tian God Temple has a donation boxes called "Tian You Xiang". All of the money raised from believers is managed by the Association of the Elders. And it is also the main income of the Association of the Elders. In addition to the expense on the day-to-day running and big celebration activities related to the temple, those money will also be used for clan festivals, as well as village education, other cultural events and so on. "Bai Laogong" and "Bai Laoye" as said before are the biggest events in Xiadi, and they are especially hold in large-scale at the beginning and the end of the Chinese New Year. Activities involve a large sum of money, for the sake of fairness and transparency, the Association of the Elders will publish a list of the income and expense details at two times each year. One is published at the Xuan Tian God temple in the early year, another is published at the Huang's ancestral hall after the worship events at the end of the year.

From March 2017 to March 2018, the Association of the Elders in Xiadi received more than 290,000 Yuan after holding the activities such as "Buddha's Birthday" celebration (it's actually the Birthday of the Xuan Tian God) and " the Deities Parade" (worship all folk gods in lunar January).Together with the association's savings over the years, it currently has a total of about 715,000 Yuan. 386,800 Yuan of them are regularly deposited as start-up funds for the rehabilitation of the Huang's ancestral hall. In terms of expenditure, it mainly includes expense on "clan", "Temple" and "education and culture" three items. Among them, "clan" includes the preparation and the hold of all kinds of ancestor worship activities, the ceremonial exchange of the Huang's clan villages, the management of ancestral halls, the condolences of the old clan, the relief money, etc. "Temples" include the organization and preparation of various gods worship activities, the management of temples, etc. "Education and culture" includes funding for cultural expenditures such as maintaining the Huang Wuxian Memorial Museum and rewarding to teachers of Xiadi Primary School. (See Table 2)

Table 2 Expenditure Summary of the Association of the Elders (2017.03-2018.03)

Category	**Expenditure/Yuan**	**Proportion**
Clan	75,793	35.4%
Temple	91,194	42.6%
Education & Culture	47,156	22.0%
Total	214,143	100%

The folk beliefs and ancestor worship in Xiadi have different rituals and activities like we saw on the surface, but they are both actually hold in hands of one practice subject "the Association of the Elders". All of the money collected from the holy temple are used not only on sacred items but also on secular need of the can.The belief relationship, we usually see as an individual subject to society in institutional religion, in here is born to be one thing inside the village or even more the clan. The social meaning of folk belief therefor has beyond the limit of belief field. About the social meaning of the religion or its institution and function, there are two different interpretation methods in sociological study of religion, Weber and Durkheim. In Webb's view, religion is a social fact and the study on it is more about analysis and interpretation of its form and function, while in the analysis of Durkheim, the essence of religion is "society." Here, we may use Durkheim's way to analyze the social meaning of folk belief and the construction of its sacred relation.

7 IS THE SOCIAL MEANING OF FOLK BELIEF AN EXTERNAL CHARACTERISTIC OR AN INTRINSIC ESSENCE?

In 1912, Durkheim published "*The Elementary Forms of the Religious Life*". In this book he defines religion as "a unified system of beliefs and practices relative to sacred things, that is to say, things set apart and forbidden—beliefs and practices which unite into one single moral community called a Church, all those who adhere to them." [13] But what is the sacred thing? Durkheim believes that the sacred thing is the manifested, personified collective ideas or group power, in fact, the society itself. In other words, "the idea of society is the soul of religion" [13]

Unlike Durkheim, Weber shelved the discussion of the essence of religion, shifting the focus of his research from the essential problem to the study of religious practice behavior.[①] Weber believes that religious behavior is rational and oriented to **This World**. It follows rules of experience. Weber believes that primitive people do not see things like our

[①] Weber at the beginning of the book "Religious sociology" said " The essence of religion is not even our concern, as we make it our task to study the conditions and effects of a social action." Weber: Max Weber. *The Sociology of Religion*. Beacon Press, 1993, p1.

modern humans. They distinguish between the greater or lesser. On the extraordinary powers, a kind of primitive belief called Geisterglaube (belief in spirits) born, which is the source of the magician's Charisma. On this basis, the extraordinary "being" is symbolized and personified as a tribal deity. After that, ancestor worship, house priest, political groups, local gods, monotheism and other religious forms known to modern people gradually formed. Based on this view of origin, which is attributed to the difference of primitive people's thinking, Weber laid aside the discussion of the essence of religion. Subsequently, in the book "*The Sociology of Religion*", he focused his exposition on prophets, sacrifices, religious ethics, taboos, religious community and so on.

Durkheim and Weber's studies on religion represented two approaches to the study of the sociology of religion, the former equated religion with society and traced the social essence of religious origin and religious sanctity, while the latter regarded religious belief as a form of behavior and, as a social fact, analyzed the relationship between its various elements and society. Weber's way of studying, which see religion as a social fact, influences the study of religion in later sociological function theory, conflict theory, compensation theory and so on. In the functional theory of Parsons, Morton and others, religion has become a part of the integration function in the social system. In conflict theory, religious organizations are regarded as one of the interest groups in the social system. In the theory of compensation, religion becomes a human organization committed to general compensation. [14] These theories have a unified feature. They see religion as an independent entity isolated from many social relations, then analyz its function towards whole relationship of society.

So, does the folk belief in Xiadi become an independent entity and run in its own way?

Judging from previous description, the practice subject of the folk belief of "Xuan Tian God" in Xiadi is actually the clan organization, and its management has been presided over by the Association of the Elders. Even when the Buddhist Lodge entered Xiadi and Buddhism splits out of the Association of the Elders. It is still influenced by the clan organization. This kind of same-subject characteristic of folk belief organization and clan organization in social relations lead to the situation that Worshipping Ancestors and Worshipping Gods can be fused in the income and distribution of money, even though they are supposed to be different faith. The expenditure of three aspects of "Clan", "temple", "education and culture" means that these money collected from Xiadi finally returned to the collective of the Huang's family. The folk belief of Xiadi has its individual festivals and rituals, however, from its social meaning, it seems that this alienation is not out of the Durkheim's "the idea of society" scope.

8 BASED ON "THE LAW OF HUMAN BEING", FOLK BELIEFS IN CHINESE VILLAGES IS CONSTRUCTING THEIR UNIQUE SACRED RELATIONSHIPS

In his book "*The Sacred Canopy: Elements of a Sociological Theory of Religion*", Peter L. Berger divides the study of religion into two parts, one part is the system of religion and the other is the religion of history. Berger believes that the core of the religious system is its theodicy part**,** which provides plausibility structure to make people's relationships orderly. "Religion makes people build sacred cosmic activities." he says in his book. To put it another way, "religion uses divine means to make order."[15] Thus, behind the construction of the sacred relationship of religious beliefs is actually the "Law of Human Being".

The belief relationship in Xiadi, as mentioned above, seems to explain the extension of the "Law of Human Being" in the "sacred relationship". Chaoshan district has always been a place whose Chinese clan culture is relatively well preserved, and this strong cultural tradition (social order in essence) has also affected the important ritual of the Xuan Tian God belief——"the Deities Parade" activities.

On 5th January of the lunar new year in 2017, "the Deities Parade" celebration held like the past years in Xiadi. The parade started from the Xuan Tian God Temple, went along the village for one circle, through the Market, Huang Jinfu's mansion, Xiadi Primary School, and other important public places, to the Huang's ancestral hall as the end. On 7th January, "The Deities Parade" team stared from the ancestral hall, walk to the big ancestral hall (the Zhichang Ancestral Hall dedicated to the first-generation ancestor of Huang's clan) of the village called Pushang nearby and finally returned to the Xuan Tian God Temple.

From the management of temples and the distribution of the money collected from temple, to the practice and symbol of faith rituals, all of which have the full participation and deduction of the secular social order. The Xiadi case reflects a constructed sacred order based on social relations. This kind of construction model, like Durkheim's exposition of the social origin of religious belief, the construction of sacred relationship is also formed around "the idea of society" and "the survival goal of ethnic groups". Religious belief in here therefore is fundamentally a kind of "belief of relationship" based on community. Interpersonal relations determine the relationship between human and God, and social order directly affects the construction of sacred relationship.[16] The social meaning of folk belief is therefore not only an organizational relationship characteristic here, but also not limited to the mosaic relationship of "dual relationship of subject and object" (belief organization-social structure), but the core of folk belief, which can be integrated into the foundation of society. Therefore, folk belief constructs a unique sacred relationship which is different from the institutional religion and crosses the divine and the secular. On its surface, it seems to be secular and utilitarian, but in its inside, it has its own sanctity and legitimacy which stems from collective consciousness and social order.

COMPETING INTERESTS

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THE CURRENT SITUATION AND ITS COUNTERMEASURES OF ENGLISH LEARNING ENGAGEMENT OF SCIENCE AND ENGINEERING STUDENTS IN BLENDED LEARNING ENVIRONMENT

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Abstract: In the post-pandemic era, blended learning has become the new trend in modern education. Learning engagement is a key factor in improving students' academic quality. Therefore, examining students' learning engagement in blended learning environments is crucial for assessing their subjective initiative, evaluating the achievement of teaching objectives, and enhancing learning and teaching effectiveness. "English learning engagement" refers to the application of learning engagement theory to the field of English language learning. However, existing research has paid insufficient attention to the English learning engagement of Science and Engineering Students. This study investigates the current state of English learning engagement among Science and Engineering Students in a blended learning environment, focusing on three dimensions—behavioral, emotional, and cognitive engagement. Based on the identified issues, targeted improvement strategies are proposed.

Keywords: Blended learning environment; English learning engagement; Science and engineering students

INTRODUCTION

The Ministry of Education issued the Guiding Opinions on Deepening the Reform of Education and Teaching in Colleges and Universities Affiliated to the Central Department on June 13th, 2016 (Jiaogao [2016] No.2), which clearly pointed out that it is necessary to promote the deep integration of information technology and education and teaching, promote the online and offline blended teaching in colleges and universities, and advance the student-centered reforms in teaching and learning methods. In the era of rapid development of information technology, "Internet+education" has become the general trend. Online learning platforms such as China University's MOOC (massive open online course), Xuexi Qiangguo, Xuexitong, and DingTalk have emerged and continuously improved, providing more possibilities, choices and help for college students' online English learning. Especially in the post-epidemic era, blended learning has become the new normal of modern education and an important form to improve students' academic quality [1].
In 2019, the Ministry of Education's "Implementation Opinions on the Construction of First-class Undergraduate Courses" proposed "increasing students' learning input", which marked that the term "learning input" was formally incorporated into the national policy discourse system [2]. Learning engagement is the key content to improve students' academic quality [3]. Therefore, paying attention to students' learning engagement in mixed learning environment is of great significance to examine students' subjective initiative, test the achievement of teaching subject goals, and improve learning and teaching effects. At present, English learning in blended learning environment is developing vigorously in a good direction, but the challenges and problems it faces can not be ignored, especially the lack of research on English learning input of science and engineering students.

1 THE THEORETICAL BASIS

1.1 Blended Learning

Blended Learning, also referred to as hybrid learning or integrated learning, is the product of the deep integration of modern information technology and education. Researchers at home and abroad have defined the concept of blended learning from different angles. Although there are some differences in expression, the essence consistently reflects that blended learning is not merely a mechanical combination but rather an effective integration of diverse instructional methods and resources to maximize teaching effectiveness [4], which has potential advantages in promoting learning engagement [5].

1.2 The Blended Learning Environment

The concept of Blended learning environment comes from blended learning. Due to different perspectives, the academic circles have different definitions of blended learning. In a narrow sense, blended learning environment refers to the combination of traditional classroom space and online teaching platform [6]. Broadly speaking, the focus of blended learning environment lies in the integration of online digital learning environment and offline physical learning

environment, and at the same time brings the integration of other teaching elements, such as teaching methods, resources, models, etc. Its main purpose is to optimize learning effect and improve learning quality.

1.3 Learning Engagement

The concept of "learning engagement" first appeared in the field of educational psychology, which mainly refers to the psychological input and efforts made by learners when learning, understanding or mastering knowledge and skills [7]. With the expansion of research, the scope of learning engagement gradually covers learners' input in actual behavior and personal feelings [8]. Researchers have put forward many theoretical models to define the conceptual dimensions of learning engagement, among which the most representative and widely applied is the "three-dimensional model "by Fredricks et al. (2004) [9]. This model posits that learning engagement consists of behavioral, cognitive, and affective dimensions. Behavioral engagement refers to learners' observable actions and participation in the learning process, such as adhering to classroom rules and engaging in discussions. Cognitive engagement is manifested in learners' use of various cognitive strategies and learning strategies in the learning process, and their efforts to understand knowledge or master skills, such as problem solving and self-regulation. Emotional engagement is embodied in learners' emotional attitudes in the learning process, such as love and happiness. "English learning engagement" refers to the transfer of learning engagement to specific disciplines.

Therefore, the success of college students' English learning in a blended environment depends on the interaction of three dimensions of learning engagement, namely, behavior, emotion and cognition, which affect each other and are inseparable. Only by working together can they form a lasting and positive emotion and cognition, enhance internal and external driving force and urge students to learn actively.

2 THE CURRENT SITUATION OF COLLEGE STUDENTS' ENGLISH LEARNING INVESTMENT IN THE BLENDED LEARNING ENVIRONMENT

An online survey of English learning engagement of science and engineering college students in blended learning environment (hereinafter referred to as "engagement survey") involves three dimensions: behavior, emotion and cognitive engagement. Among them, behavioral engagement includes three dimensions: autonomy, cooperation and persistent learning, emotional engagement includes three dimensions: learning willingness, learning experience and value recognition, while cognitive environment includes three dimensions: metacognition, cognition and resource management strategies. The main findings are as follows:

Firstly, the English learning engagement of science and engineering students in the blended learning environment is not optimistic as a whole. Specifically, behavioral engagement is the highest, emotional engagement is the second, and cognitive engagement is the lowest. Learning autonomy under behavioral engagement and learning willingness under emotional engagement are not strong, and metacognition and cognitive strategies under cognitive engagement are seriously lacking. Specific to the differences in gender, major and grade, there are significant differences in behavioral engagement, emotional engagement and cognitive engagement between male and female students. There is no significant difference in students' learning engagement in majors. There are significant differences in students' behavioral engagement and emotional engagement among different grades, but there is no significant difference in cognitive engagement among different grades.

Secondly, the time devoted to English learning is seriously insufficient. A striking 50.81% of students reported studying English for less than 0.5 hours per day, while only 12.47% devoted more than 1.5 hours daily. This indicates that the majority of students allocate minimal time to English learning, reflecting a general lack of engagement with the subject.

Thirdly, the awareness of English autonomous learning is weak. College English is a public compulsory course, accounting for a certain number of credits. In order to graduate smoothly, students will try their best to improve their learning efficiency and strive for credits. Most students tend to finish English learning tasks passively, and few students learn English independently, often "studying for exams" or "studying for learning". Moreover, their avenues for engaging with English learning remain limited, with most relying solely on passive classroom instruction.

Fourthly, emotional engagement varies from person to person. Students' interest in English, students' English foundation, teachers' teaching style and personal charm are all influencing factors.

3 STRATEGIES TO SOLVE COLLEGE STUDENTS' ENGLISH LEARNING ENGAGEMENT PROBLEM

The above problems can be solved from the following aspects through literature research and teaching practice:

3.1 Optimizing Learning Methods and Enhance Cognitive Engagement

College students should recognize the situation clearly, renew their learning philosophies, keep up with the pace of the times and optimize their learning methods. In order to learn English well, students must adopt blended learning methods, combine face-to-face traditional learning with online learning, and learn the advantages of various learning methods. On the one hand, students should make full use of the advantages of the platform, use rich and colorful English resources to expand their knowledge, internalize the language foundation, actively participate in the discussion activities of the platform, exchange and discuss the problems encountered in learning, realize common learning progress, accumulate basic English knowledge and increase the continuous motivation of learning; On the other hand, students should make

full use of classroom learning opportunities, actively participate in classroom activities such as group tasks and speeches, and improve their communication self-confidence and cross-cultural communication skills.

3.2 Stimulating Learning Motivation and Promote Emotional Engagement

Stimulating learning motivation can be considered from two aspects: learning interest and autonomous learning consciousness. Fully realize the value and importance of English learning. In addition, students should improve their awareness of autonomous learning. First of all, we need to be clear about our dominant position and give full play to the role of English learners. As many students have mentioned, “If we don’t study ourselves, it won’t help even if the outside world creates the best conditions”. Secondly, students should establish the awareness of English autonomous learning, develop the habit of English autonomous learning, and shift from a passive mindset (“I have to learn”) to an active one (“I want to learn”), gradually explore the suitable English autonomous learning methods, and flexibly apply them to English learning activities to truly realize “learning to learn”.

3.3 Clarifying Clear Learning Objectives and Increase Behavioral Engagement

Non-English majors’ feelings and attitudes towards English learning vary by individual and discipline, yet they share common learning objectives, but they share the same learning goal. Superficially, college students’ goal of learning English is to pass various exams, such as final exam, CET-4 and CET-6, national talent exam, postgraduate entrance examination, etc. However, from a long-term perspective, learning English is for career development and further study and communication. In today’s information-exploded global village, English has become one of the lingua franca, and international communication and cross-cultural communication are becoming more and more normal. Students should be aware of this situation, take an active part in online and offline learning activities, study hard, and gradually improve their language skills such as listening, speaking, reading, writing and translation, so as to lay a solid foundation for future success. Moreover, blended teaching emphasizes the implementation of students’ dominant position in learning, and also attaches importance to teachers’ leading role. Only by organically combining students’ subjectivity with teachers’ dominance can we achieve the best learning effect. Before class, students’ autonomous learning can not be carried out without the guidance of teachers’ clear teaching objectives. Teachers should make clear the learning task objectives and the completion time, so that students can examine their learning behavior against the task objectives. Teachers give feedback on students’ practice and testing in face-to-face class, organize students to carry out activities such as classroom observation and comments, guide students to monitor their learning process, and students adjust their learning status in time to reflect on their mastery of knowledge.

4 CONCLUSION

Blended learning effectively promotes the organic integration of online teaching resources and offline classroom teaching, realizes the complementary advantages of traditional learning methods and online learning methods, and extends the learning time and space. Students’ English learning investment in behavior, cognition and emotion is directly proportional to their learning results. The greater the learning investment, the higher the learning efficiency and the better the blended learning effect.

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THE DUAL EFFECTS OF A COUNTRY'S OVERSEAS PATENT NETWORK LAYOUT ON ITS EXPORT: SCALE-UP OR QUALITY IMPROVEMENT

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Abstract: It is an important measure for a country to consolidate and enhance its international competitiveness by constructing an overseas patent network. In this paper, we study the mechanism and dual effects of a country's overseas patent network on its export performance from the perspectives of the breadth, depth and quality of the network by using the overseas patent data of 60 countries from 2000 to 2018. The main conclusions are as follows: (1) The breadth and depth of overseas patent network and the proportion of the overseas invention patent applications have significant positive influences on a country's export quantity and export quality, while the proportion of patent applications in developed countries is negatively related to export quantity and export quality. (2) The effect of the breadth of overseas patent network on export quantity is "U-shaped", and the effect on export quality is "reversed U-shaped". Besides, the "reversed U-shaped" relationship can also be found between the depth of overseas patent network and export quantity and export quality. We also find that some countries have excessive patent layouts in developed countries. (3) The heterogeneity analysis reveals that differences in types of countries and patents can affect the effects of the overseas patent network. For example, both the breadth of overseas patent network and the proportion of the overseas invention patent applications have greater impacts on export quantity in the developed country than in the developing country, while the effects of the depth of overseas patent network and the proportion of patent applications in developed countries on export quantity and export quality in the developing country are greater than those in the developed country. The study makes a marginal contribution to the existing theories about the impact of the overseas patent network on export performance, and provides some theoretical references for countries, especially developing countries, about adjusting overseas patenting strategies.
Keywords: Breadth of overseas patent network; Depth of overseas patent network; Export quantity; Export quality

1 INTRODUCTION

The flow of innovation factors has greatly contributed to the growth of global patent applications. Statistics from the World Intellectual Property Indicators Report 2024 (WIPI) show that global patent application activity reached a new high in 2023, with the number of applications exceeding 3.5 million for the first time, marking the fourth consecutive year of growth in global patent applications despite the challenging macroeconomic environment. As the world trade and investment links become increasingly close, more and more countries accelerate the pace of overseas patent layout, the complexity of overseas patent network is further strengthened, the coverage is expanded, and the degree of concentration and quality level is also continuously upgraded. However, in terms of the overall scale of overseas patents, there is still a huge difference between developed countries and developing countries, and although China has jumped to the first place in the world in terms of the number of PCT patents applied, the proportion of overseas patent applications is still only 6.7%, far lower than that of developed countries such as Germany with 59.4%, Japan with 46.3%, and the United States with 45.6%, etc. The total amount of overseas patent application of the United States is 2.3 times of that of China. For different economies, the overseas patent layout of developed countries is becoming more and more perfect, and the main purpose of their overseas patent strategy is to consolidate and enhance the advantages of the existing patent network and expand more target markets, so as to be able to form a more diversified patent network advantages. Most developing countries are still in the initial stage of overseas patent layout, while large developing countries such as China and India are accelerating their overseas patent layout in an all-round way in order to form a global patent network advantage. Overseas patents reflect the degree of recognition of the importing country for the products or technologies of the home country, which is a measure of the innovation ability of the home country and an important weapon to gain competitive advantage in exports [1]. Therefore, it will be of great theoretical and practical significance to explore the mechanism and multiple influence effects of overseas patent network layout on a country's export.

Identifying the internal dynamics of a country's exports plays a crucial role in its economic development[2]. Previous studies have focused on the factors influencing export size and export technological complexity. At the micro subject level, outward foreign direct investment expands the depth margin and breadth margin of exports, thus affecting the technological complexity of firms' export products[3]; at the macro subject level, technological intensity drives a country's export growth by affecting efficiency[4], and FDI, institutional quality, intellectual capital, and infrastructure

are also export quality key factors for the improvement of export quality[5-7]. Many scholars have explored the influencing factors of exports from the perspectives of different subjects, such as institutional quality, economic conditions, and intellectual capital.

Closer global trade linkages have led to more business opportunities and risks of imitation, prompting knowledge owners to seek knowledge or technology protection abroad, which has facilitated the diffusion of innovations globally and contributed significantly to the growth of the world economy[8-10]. Studies have examined the relationship between innovation and export trade, using the number of patents as the main indicator of technological output. Zhou et al. used the number of patent applications as a proxy variable for innovation performance, and elucidated the mechanism of the impact of export trade of listed companies on corporate innovation from the perspectives of economies of scale and risk-taking. Other scholars explored the innovation value of patents from different sources [11]. Yu Daoxian and Liu Haiyun differentiated between the number of domestic patents granted and the number of foreign patents granted to study the impact of technological innovations from different sources on China's export trade, and found that technological innovations from foreign countries had a stronger promotion effect on China's export trade [12]. Ozsoy et al. (2021) also found that patent applications from foreign countries promoted the technological sophistication of the host country's exports. Other studies used the filing or granting of patents abroad as a measure of a country's innovative capacity [13].Blind and Jungmittag used the number of patents filed by Germany at the European Patent Office as a technological indicator of innovation and standards, and found that Germany's innovative capacity explains its export performance [14].Chen using the number of patents granted in the US as a technical indicator, examined the marginal export effect of innovation in manufacturing industries in 105 countries [15]. The results showed that innovation affects export performance mainly along the intensive margin. Compared with domestic patents, overseas patents better reflect the degree of recognition of home country innovations in the host market and are more suitable for the study of export trade issues.

Most studies have explored the impact of the innovation value of patents on export trade, but the complexity and structure of patent networks have received little attention, and there is a paucity of research based on the breadth, depth and quality perspectives of patent networks. The impact of the characteristics of a country's overseas patent network layout on exports, as the main body of patent layout, is also generally ignored. Among the existing studies, Cai Zhonghua et al. constructed a similarity index, pointing out the relationship between China's patent layout in the 'Belt and Road' countries and the structure of exports, but did not explore the mechanism of the impact of overseas patent network layout on exports [16]. Li Jieyu et al. explored the dual effect of product innovation and process innovation of overseas patents by investigating the performance of overseas patents of various countries in the U.S. market [1]. Willoughby pointed out that there is a causal relationship between the behavior of foreign international patent applications and domestic economic development, but the internal mechanism of the relationship is not clear [17].

Does the construction of overseas patent networks contribute to the growth of a country's export quantity, or does it improve the quality of a country's exports, or does it have both effects and which one is dominant? What are the differences in the impact of the breadth and depth of patent networks on the quantity and quality of a country's exports? What are the differences between the export effects of patenting in developed countries and those in developing countries? Is there a problem of over-layout in developed countries? The answers to these questions are particularly important for developing countries that are accelerating their overseas patent deployment. The marginal contribution of this paper is mainly in the following aspects: (1) putting the breadth, depth and quality dimensions under a unified analytical framework, exploring the dual impact of the structural characteristics of overseas patent networks on the quantity and quality of a country's exports, and expanding the existing research results on the impact of overseas patent network layout on exports. (2) Explore the non-linear relationship between the breadth, depth and quality of overseas patent networks on the quantity and quality of exports, and clarify the intrinsic mechanism between the layout of overseas patent networks and exports. (3) Examining the heterogeneity of different types of countries and different types of patent layouts to further deepen the understanding of the mechanism of the effect of the breadth and depth of overseas patent networks on exports.

2 THEORETICAL MECHANISMS AND HYPOTHESES

It has been shown that there is a significant positive correlation between technological performance represented by patents and export performance represented by export market share[18]. So how would the characteristics of a country's overseas patent network affect the quantity and quality of its exports? What are the underlying mechanisms? In the following paper, we will specifically discuss the mechanism of the breadth and depth of overseas patents on the quantity and quality of exports respectively.

2.1 Theoretical Mechanism of the Breadth of Overseas Patent Networks on Export Quantity and Export Quality

Technical barriers to trade have gradually developed into one of the means of trade protection in many countries[19], and overseas patents can, to a certain extent, alleviate the impact of patent barriers such as technical barriers and market access on trade[20]. Overseas patents are the 'entry ticket' for a country to enter the overseas market, but also a way to compete for market share and obtain high profits. In the highly competitive international market, for a country, the wider the overseas patent network means that the country legally holds the relevant patents in more countries, the smoother the country will enter more overseas markets, which will help to broaden the sales channels of export products

and increase the country's export scale. At the same time, according to the new trade theory, when the size of the export market increases, the productivity of the whole industry will be increased accordingly due to the reallocation of resources. This means that after a country succeeds in joining overseas markets and broadening its export scale, it can greatly increase its risk-taking by learning and making full use of the host country's knowledge, experience, technology and other factors. Risk-taking can promote firm innovation[21-22] and increase the level of technology and productivity in the home country. As productivity increases, the marginal cost of export products decreases and the quality rises[23-24], which in turn enhances export stability and improves export competitiveness[25].

However, the positive effect of the breadth of overseas patent networks on the quantity of exports may have a threshold effect, which means the effect of the breadth of overseas patent networks on the quantity of exports of a country may not be significant when the country holds patents in only a few countries. Firstly, the home country has fewer international markets to expand because of its patent holdings, and fewer intangible assets such as knowledge and experience that can be learnt and acquired in the new market environment. At the same time, the degree of coupling between the knowledge and other intangible assets extracted from different regions may be lower, and the resources acquired by the home country are more different. If the home country wants to make real use of the acquired resources, it will take a certain amount of time and capital investment, and the cost of adopting new knowledge and new technologies will also weaken the advantages brought by the breadth effect of overseas patent networks. In addition, due to the acquisition of fewer intangible assets, the change in the level of technology in the home country is not obvious, and the increase in productivity is not significant. However, when the breadth of overseas patent network reaches a certain amount, the positive effect of patent breadth on the number of exports will become more obvious. Firstly, as the breadth of overseas patent layout increases, the home country acquires more resources from the host country, the coupling of resources will gradually increase, the accumulation of related knowledge leads to similar innovations, and it is easier to realize the transfer and integration of technology[26] , and the marginal cost required to be spent on integrating the new knowledge and new resources will be gradually reduced, and at this time, the overseas patent network breadth brings the advantage of reducing production costs will also be more obvious. In addition, the more patents a country holds and the more overseas markets it enters, the more international competition the home country will face. In order to increase its advantage in international competition, the risks associated with fierce competition will also stimulate technological innovation[11], which will help to produce products of better quality[27], as well as increase productivity to reduce production costs, thus increasing the number of exports from the home country. Therefore, there may be a threshold effect of overseas patent network breadth on the number of exports, and the positive effect of patent breadth on the number of exports will become more and more obvious only when the breadth of overseas patent network reaches a certain number.

In addition, resource fragmentation, increased additional regulatory concerns, and technical barriers may undermine the contribution of improved export product quality from increased breadth of overseas patent networks. On the one hand, when the breadth of a country's overseas patent network becomes wider, the country's overseas market layout becomes wider, and the human and organizational resources of the home country will be dispersed to more overseas markets. This means that as the breadth of the overseas patent network increases, while the home country continues to absorb and assimilate more resources, these resources are gradually dispersed into more shares, and the role of the level of innovation and technology in stimulating the improvement of the quality of export products gradually diminishes. On the other hand, overseas expansion brings more uncertainty in several areas; e.g., the wider the patent network, the more potential competitors or infringers one faces[28], which requires more managerial attention to be invested in controlling risks to cope with these additional uncertainties[29-31], and accordingly the home country's attention and focus on export quality decreases. Moreover, when the technical level of the production products is improved to a certain extent, it is inevitable that technical barriers will be encountered, and it is more difficult to improve product quality, the enthusiasm for technological innovation will be weakened, and the benefits of innovative technology investment will gradually diminish. Therefore, when the Overseas Patent Breadth reaches a certain level, the positive effect of the Overseas Patent Breadth on the quality of exports will gradually diminish.

The mechanism of the Overseas Patent Breadth and the quantity and quality of exports is shown in Figure 1:

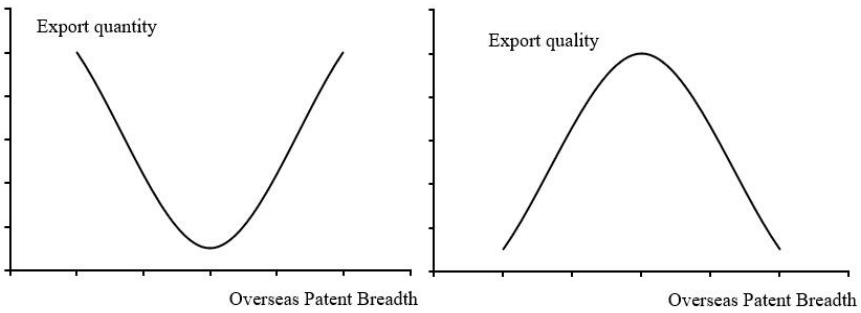

Figure 1 Mechanism of the Overseas Patent Breadth

This paper proposes:

Hypothesis 1: The relationship between the breadth of overseas patent network and the number of exports is ‘U-shaped’, that is, the number of exports decreases with the increase of the Breadth of overseas patent network, and when it

exceeds a certain threshold, the further increase of the Breadth of overseas patent network positively contributes to the increase of exports quantity.
Hypothesis 2: The relationship between the breadth of overseas patent network and the quality of export is in an 'inverted U-shape', that is, the quality of export improves along with the increase of the breadth of overseas patent network, and when it exceeds a certain threshold, the further increase of the breadth of overseas patent network inhibits the increase of the quality of export.

2.2 Theoretical Mechanisms of the Depth of Overseas Patent Networks Affecting the Quantity and Quality of Exports

The depth of a country's overseas patent network has an incentive effect on the quantity and quality of its exports. The depth of the overseas patent network refers to the number of patents applied for or granted by the home country in the host country. Firstly, deeper depth means that the home country is better able to understand the host country's environment and acquire different local knowledge. Increased familiarity with the local environment weakens the 'outsider disadvantage', which is conducive to the further expansion of the market scale, and also makes it easier for intangible assets such as local knowledge to be digested and integrated[26] , which stimulates the upgrading of the home country's technological level, promotes the improvement of the quality of exported products and reduces the marginal cost of production, and creates economies of scale. Secondly, the improvement of the depth of a country's overseas patent network can avoid encountering patent barriers in terms of industry competition, etc., and can reduce the risk of encountering patent litigation as well as the related compensation, coordination and other costs[20], reduce transaction costs, incentivize the country's export behaviors, and increase investment in innovative technologies.
However, when the depth of a country's overseas patent network reaches a certain value, the incentive effect of patent depth on the quantity and quality of exported products may be constrained. Firstly, when the depth of the overseas patent network of the home country gradually deepens, the level of science and technology and productivity also continue to increase, but when the depth of the overseas patent network reaches a certain value, the production technology of the home country is prone to technical barriers, the incentive to innovate products will be weakened, and the marginal benefit of investment in technological innovation will also be reduced. Secondly, due to the 'self-selection' effect[32], some of the higher productivity enterprises in the home country will give up exporting and choose outward foreign direct investment[33], and the export scale of the home country will be affected. Thirdly, there is a level of technological spillover from the home country's product technology in the process of overseas trade, which will play a role in demonstrating, stimulating and promoting technological innovation for the host country's competing enterprises in the same industry [34], resulting in the effect of technological diffusion and the effect of 'learning by doing', and to a certain extent, it will give competitors more opportunities to learn or imitate, and even some other exporting countries can improve the quality of their own export products by obtaining innovation benefits through 'learning from exporting' [35] , which will lead to the weakening of the value of the home country's export products and the reduction of the competitiveness of export products, which is unfavorable to the home country's product export trade. Fourth, with the deepening of a country's overseas patent network, it may form a monopoly in the host country, which is unfavorable to the exports of other prospective exporters[36] and impedes the free competition in the local market, at which time the relevant enterprises in the home country are susceptible to the suppression of the local government or relevant industries. At the same time, due to the monopoly effect, the home country's innovation enthusiasm will be weakened, the investment in technological upgrading and transformation will be reduced, which is not conducive to the export behavior of the home country and the further improvement of the technological level.
The benefit function of overseas patent depth is convex, as the depth of overseas patents increases, the degree of familiarity with the local area increases, the 'outsider's disadvantage' is weakened, and the home country's access to local knowledge and other resources increases. However, the benefit of patent depth has a certain limit, when the depth reaches a certain value, the home country completely internalized the host country's market resources as well as the knowledge gained from competitors, the increase in benefits will tend to converge[26]. The cost function of overseas patent depth is concave, with the increase of overseas patent depth, the patent rights will overlap with each other, and it is easy to form the phenomenon of 'patent jungle', and the intricate dependence relationship between patents will increase the cost of patent implementation[37]. The mechanism of the depth of overseas patent network and export quantity and quality is shown in Figure 2:

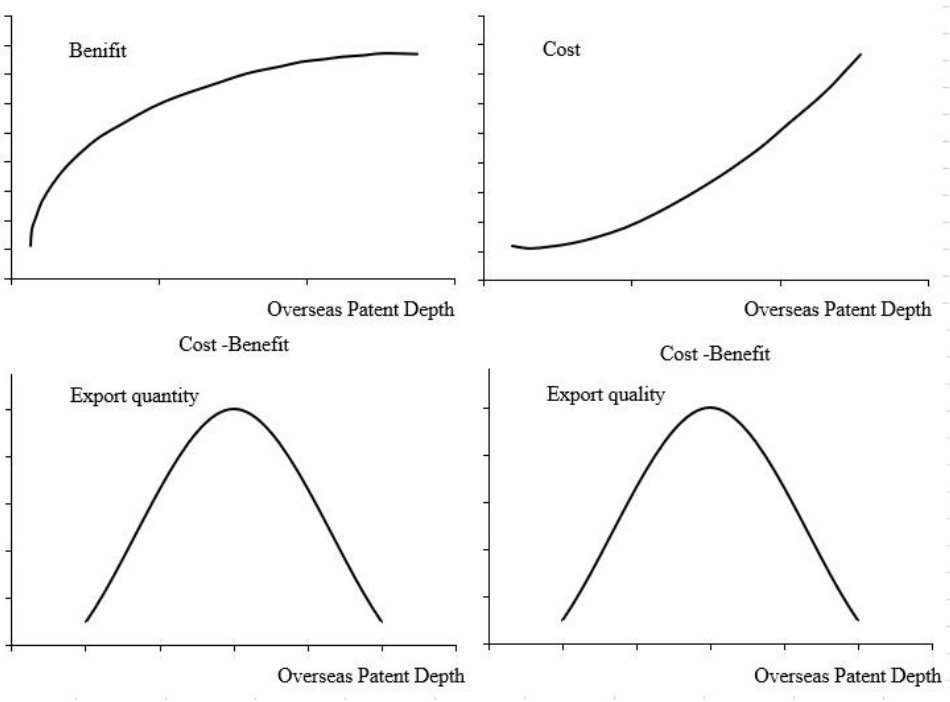

Figure 2 Mechanism of the Role of Depth of Overseas Patent Network

This paper puts forward the following hypothesis:
Hypothesis 3: The relationship between the depth of overseas patents and the quantity and quality of exports is in an inverted 'U-shape', which means the quantity and quality of exports increase and improve along with the increase in the depth of overseas patents, and when a certain threshold is exceeded, the further increase in the depth of overseas patents inhibits the increase in the quantity of exports and the improvement of the quality of exports.

3 VARIABLE MEASUREMENT AND DATA SOURCES

3.1 Measurement of Variables

3.1.1 Measurement of export quantity and export quality indicators

The explanatory variables in this paper are export quantity and export quality, export quantity (EXW) is expressed by the export value, the unit is 1 billion US dollars; export quality (EXQ) is expressed by the export technological complexity TSI, this paper draws on the measurement method of Lall et al. (2006) [38], Rodrik (2006) [39], a country's export technological complexity specific calculation process is as follows:
Firstly, the technical complexity of a country's exports of a product g is calculated by using equation (1). Using equation (2) to calculate the export technical complexity of each country, the specific formula is as follows:

$$PRODY_g = \sum_c \frac{\left(x_{cg}/X_c\right)}{\sum_c \left(x_{cg}/X_c\right)} PGDP_c \tag{1}$$

$$\mathrm{TSI}_{it} = \sum_g \left(\frac{x_{cg}}{X_c}\right) \cdot PRODY_g \tag{2}$$

where, denotes exports of country c product g, is country c's total exports, is country c's gdp per capita in constant 2011 US dollars and purchasing power parity, in US dollars, denotes country c's exports of product g, is country c's exports, and exports are all expressed in US dollars.

3.1.2 Measurement of indicators of the breadth, depth and quality of overseas patent networks

The explanatory variables in this paper include overseas patent network breadth, depth and quality. Overseas Patent Network breadth (GD) is constructed by using the number of countries that are the target of a country's overseas patent applications, and the larger the number of countries that are the target of applications, the wider the scope of overseas patent layout. Overseas Patent Network Depth (SD) is expressed as the ratio of a country's total number of overseas patent applications to its breadth, and is used to describe the average level of overseas patent applications among host countries. Meanwhile, in order to examine the impact of different types of overseas patent network layouts on exports, i.e., the impact of the breadth and depth of overseas invention patent networks, utility model patent networks and design patent networks on the quantity and quality of exports, this paper also measures the breadth and depth indicators of the

three types of overseas patent networks. Compared with utility model patents and design patents, invention patents have a higher degree of innovation, so this paper constructs the proportion of overseas invention patent applications (IPP) indicator as an indicator of the quality of a country's overseas patent network. The larger the proportion of overseas invention patents, the higher the quality of the patent network. At the same time, this paper also measures the proportion of developed countries in the target countries of overseas patent applications (PDC) as an indicator to describe the quality of overseas patent network, the higher the proportion of patent layout in developed countries, the higher the quality of overseas patent network.

3.1.3 Control variables measurement

By combing through the relevant literature, this paper selects the following indicators as control variables: resource endowment, foreign direct investment, the level of outward foreign direct investment, the level of technology and the level of education expenditure. The specific indicators are described as follows:

(1) Resource endowment (RES): the richer a country's resources are, the more favorable it is to the increase of export scale, which also has an impact on export quality. In this paper, the share of fuel and mineral exports in product exports is used to indicate a country's resource endowment.

(2) Foreign direct investment (FDI): the higher the level of foreign investment attraction, the more favorable to the growth of a country's export scale, and the level of export quality will be improved through technological spillovers. In this paper, the net inflow of FDI as a proportion of GDP is used to indicate the level of a country's attraction of foreign investment.

(3) The level of outward foreign direct investment (OFDI): the higher the level of OFDI, the stronger the competitive advantage of a country's market players in the host market, which is conducive to the enhancement of export quantity and quality. This paper adopts the net outflow of OFDI as a proportion of GDP to indicate the level of OFDI of a country.

(4) Technology level (TE): technology level is one of the important factors affecting the quantity and quality of exports. This paper adopts the proportion of high-tech product exports to manufactured exports to indicate a country's technology level.

(5) The level of education expenditure (EDUE): a country's increased investment in education helps to improve the level of human capital and innovation capacity, thereby increasing the quantity and quality of exports. In this paper, the total public expenditure on education as a proportion of government expenditure is used to express a country's education expenditure level.

3.2 Sample data sources

In this paper, overseas patent data and development indicator data of 60 countries in the world from 2000 to 2018 were selected. The patent data come from the World Intellectual Property Organization (WIPO), and include the application and granting of a country's invention, utility model and design patents overseas. Data on export quantities and control variables are from the World Bank Development Indicators database, and data on relevant indicators measuring export quality are from the UN COMTRADE database, using data on export products classified according to the United Nations Standard International Trade Classification Statistical Database (UNSITC) and the HS code classification, using the three-digit code classification according to SITC Rev.2. In the selection of sample countries, The initial sample for this paper was selected from the OECD-TIVA database of 66 countries, due to the limited effect of the layout of the overseas patent network is too small on the export, so this paper excludes the countries with too few overseas patent applications and the number of host countries oriented to the host country is too small, considering the availability and completeness of data on control variables, a final sample of 60 countries from 2000-2018 was selected. The sample covers OECD, EU, G20 countries, East Asian and Southeast Asian economies and South American countries, and the overseas patent applications of these countries account for more than 90% of the global PCT patent applications, so the sample has a good representation.

3.3 Descriptive Statistics of Variables

The descriptive statistics of the main variables are shown in Table 1. From the perspective of overseas patent network layout, the mean value of depth is 159.06, the median value is 21.54, and the difference between the maximum value and the minimum value is large, which indicates that the depth of overseas patent network varies greatly among the countries in the sample, and only a few of them have a greater depth of overseas patent network. The mean value of breadth is 43.07, the median value is 40, and the difference between the maximum and minimum values is also large. In terms of export quantity and export quality, there are large differences in export size and export quality between countries. The mean value of the share of patent applications in developed countries reaches 0.726, indicating that most countries have located their overseas patents in developed countries.

Table 1 Descriptive Statistics of the Main Variables

Variable	Mean	Median	Maximum	Minimum	standard deviation	skewness	kurtosis

EXW	193.60	76.04	2486.70	0.84	315.11	3.51	18.47
EXQ	23320.87	23493.79	48354.4	10011.88	4975.233	0.17151	4.149189
GD	43.07	40.00	122.00	0.00	28.12	0.42	2.37
SD	159.06	21.54	2924.43	0.00	404.43	4.36	23.44
IPP	0.71	0.79	1.00	0.00	0.22	-1.18	4.00
PDC	0.72	0.74	1.00	0.00	0.16	-2.03	9.62
RESOURSE	19.77	10.19	97.90	0.00	22.44	1.78	5.37
FDI	7.64	3.14	449.08	-58.32	27.05	10.23	131.93
EDUE	13.85	13.17	31.37	5.30	4.09	1.08	4.60
TE	17.27	13.38	90.02	0.00	13.84	1.60	5.94
OFDI	5.34	1.45	301.25	-87.23	23.69	7.18	73.76

4 EMPIRICAL ANALYSIS

4.1 Model Design

This paper tests the mechanism and effect of overseas patent network on export quantity and export quality by introducing an econometric model to test the mechanism and effect of overseas patent network on export quantity and export quality from the perspectives of breadth, depth and quality, and the benchmark model is as follows:

$$\mathrm{EXW_{it}}/EXQ_{it} = \alpha_0 + \alpha_1 GD_{it} + \alpha_2 SD_{it} + \alpha_3 IPP_{it} + \alpha_4 PDC_{it} + \Phi X_{it} + \varepsilon_{it} \quad (3)$$

Where and stand for country and year, EXW and EXQ denote a country's export quantity and export quality respectively, GD and SD denote the breadth and depth of overseas patent network respectively, IPP and PDC denote the quality of overseas patent network, and X is a collection of control variables including variables such as the level of resource endowment, the level of education expenditure, foreign direct investment (FDI), outward foreign direct investment (OFDI), and the level of technology. Meanwhile, in order to test the non-linear effects of the breadth, depth and quality of overseas patent networks on the quantity and quality of exports, we introduce the squared terms of the breadth, depth and quality variables on the basis of the benchmark model. The specific non-linear model is as follows:

$$\mathrm{EXW_{it}}/EXQ_{it} = \alpha_0 + \alpha_1 GD_{it} + \alpha_2 {GD_{it}}^2 + \alpha_3 SD_{it} + \alpha_4 {SD_{it}}^2 + \alpha_5 IPP_{it} + \alpha_6 PDC_{it} + \alpha_7 PDC_{it}^2 + \Phi X_{it} + \varepsilon_{it} \quad (4)$$

4.2 Benchmark Regression Analysis

The results of the benchmark regression are shown in Table 2, in which columns (1)-(4) report the regression results of export quantity on the breadth and depth of overseas patent network, the share of overseas invention patent applications, and the share of overseas patent applications in developed countries, respectively; columns (5)-(8) report the regression results of export quality on the breadth and depth of overseas patent network, the share of overseas invention patent applications, and the share of overseas patent applications in developed countries, respectively. The regression results in Columns (1)-(3) show that the breadth and depth of overseas patent networks, and the share of overseas invention patent applications have a significant positive effect on the quantity of exports. Controlling for other variables, in terms of the export effect of the overseas patent network, for every unit increase in the breadth of the overseas patent network, the country's exports will increase by 3.5785 units; for every unit increase in the depth of the overseas patents, the country's exports will increase by 0.3037 units; and for every unit increase in the share of patent applications for inventions abroad, the country's exports will increase by 94.1468 units. And the regression result of Column (4) indicates that the proportion of overseas patent applications in developed countries has a significant negative effect on the number of exports, which indicates that the more the proportion of overseas patent applications in developed countries is increased, the more it will inhibit the number of exports of the country. The reason may be that the proportion of overseas patent applications in developed countries is too high in most of the countries, and at this time, the cost effect and the competition effect brought by the strategy of overseas patent layout inhibit the quality of its technological innovation. the quality of their technological innovation[40], which is not conducive to further expanding the export scale of products.

The regression results in columns (5)-(7) show that the breadth and depth of overseas patents and the share of overseas invention patent applications have a significant positive effect on export quality. Each unit increase in the breadth and depth of overseas patents and the share of overseas invention patent applications corresponds to an increase in the country's export quality by 93.5052, 1.9476 and 2852.8980 units, respectively. While the regression results in column (8) illustrate that the share of overseas patent applications in developed countries has no significant effect on the quality of exports, which indicates that a change in the share of overseas patent applications in developed countries will not have an impact on the quality of a country's exports. Some studies have shown that for professional-intensive enterprises, the improvement of patent quality is only achieved by increasing the variety of exported products[41] , but not at the same time improving the quality of exported products. Therefore, when the proportion of overseas patent applications is high in developed countries, this patent quality indicator may not have an impact on the quality of export products.

Combined with the theoretical analysis in the previous section, the results of the benchmark regression show that the

overseas patent network promotes the enhancement of a country's export quantity and the improvement of export quality, and the breadth, depth and quality of the overseas patent network mainly show positive competitive and learning effects, leading to the improvement of productivity and technological level, and the decrease of production costs, so that the improvement of the breadth and depth of the overseas patent layout significantly increases the quantity of exports and improves the quality of exports.

Table 2 Impact of Overseas Patent Network Layout on Export Quantity and Export Quality

Variable	Export Quantity				Export quality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cons	-5.842*** (8.400)	78.514*** (8.311)	85.872*** (9.654)	177.460*** (17.139)	17245.24*** (470.326)	24393.89*** (433.468)	23518.44*** (763.088)	25613.91*** (1054.57)
GD	3.579*** (0.271)				93.505*** (3.365)			
SD		0.304*** (0.011)				1.948***(0.281)		
IPP			94.147*** (13.070)				2852.898*** (410.419)	
PDC				-36.275** (16.595)				-440.594 (647.116)
RES	0.9085*** (0.114)	0.6674*** (0.0657)	0.2079 (0.1320)	0.2229** (0.1094)	436.4806*** (5.7536)	12.31325* (6.5381)	3.6849 (9.1654)	7.9766 (10.1820)
FDI	-0.7607 ** (0.311)	-1.2549*** (0.3314)	-1.341*** (0.3976)	-1.7278*** (0.2991)	21.6841** (9.7640)	-8.5905 (7.7494)	-8.0735 (5.6805)	-13.7518** (6.1473)
EDUE	-1.0133** (0.419)	-3.3475*** (0.3551)	-6.574*** (0.7996)	-6.0627*** (0.5666)	-77.8269*** (27.32730)	-287.779*** (30.4587)	-338.799*** (26.3879)	-335.079*** (22.9903)
TE	1.9324***(0.237)	2.2956*** (0.2480)	2.6369*** (0.2535)	2.7008*** (0.2088)	127.5718*** (8.9089)	125.3817*** (10.9763)	122.3641*** (7.8224)	130.4418*** (8.1995)
OFDI	0.4065** (0.199)	1.0153*** (0.1786)	1.0252*** (0.2191)	1.1991*** (0.2997)	-13.5277 (9.2882)	18.6188 *** (6.7933)	19.2940** (6.3952)	21.5466*** (6.8403)
Country &	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.6253	0.4995	0.2072	0.2995	0.5896	0.2582	0.2560	0.2383
F	220.017***	131.544***	34.46***	56.362***	189.4011***	45.8808***	45.3592***	41.2486***
N	798	798	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

4.3 Nonlinear discussion

In order to examine the non-linear relationship between the layout of overseas patent networks and the quantity and quality of a country's exports, we introduce the squared terms of the breadth, depth and quality variables on the basis of the baseline model. Columns (1)-(3) of Table 3 report the results of non-linear regression of the quantity of exports on the breadth and depth of overseas patent networks versus the share of overseas patent applications that are located in developed countries respectively, and Columns (4), and (5) report the results of the non-linear regression results of export quality on the breadth and depth of overseas patent networks and the share of overseas patent applications in developed countries, respectively.

As can be seen in column (1) of Table 3, in the nonlinear model of overseas patent network breadth and export quantity, the coefficients of the primary and square terms of overseas patent network breadth are negative and positive respectively, and pass the significance test of 1%, which indicates that the effect of overseas patent network breadth on the number of exports is in a 'U-shape' in line with the theoretical expectation, which is similar to the results of Yang,

Zheng et al.[42]. Roughly estimated, the inflection point of overseas patent network breadth is 8.64, i.e. the positive effect starts to appear when the overseas patent network breadth reaches 8.64. The mean value of overseas patent network breadth is 41.32, which is located on the right side of the inflection point, and it can be seen that improving the layout of overseas patent network breadth helps to increase the number of exports, which again verifies the estimation results in Table 1. At the same time, it also shows that there is a limiting value for the positive effect of overseas patent network breadth on the number of exports, when a country's overseas patent network is in more than 8.64 countries, more and more resource accumulation and technological integration and innovation will make the positive effect of patent breadth on the number of exports gradually appear, thus hypothesis 1 is established. The results in column (4) of Table 3 show that there is an 'inverted U-shaped' relationship between the breadth of overseas patent network and export quality, with the inflection point at about 176.90, and the mean level of the breadth of overseas patent network is located to the left of the inflection point. This indicates that increasing the breadth of overseas patent layout is conducive to improving the quality of domestic exports, but when a country's overseas patent network exceeds the threshold, continuing to increase the breadth of overseas patent network may inhibit the improvement of domestic export quality due to the dispersal of resources, the increase in the cost of additional management attention, technical barriers and other problems, which proves that hypothesis 2 is valid.

The regression results in columns (2) and (5) of Table 3 show that there is an 'inverted U-shaped' relationship between the depth of overseas patents and the quantity and quality of exports, with the inflection points at about 2034.75 and 1575.58, respectively, and the mean level of the depth of overseas patents is located on the left side of the inflection points of the two models. This indicates that increasing the depth of overseas patents is conducive to improving the quantity and quality of domestic exports, but when the average number of patents in each country of a country's overseas patent network exceeds 2034.75 or 1575.58, continuing to increase the depth of the overseas patent network may result in a decrease in the quantity and quality of domestic exports due to factors such as technological barriers, self-selection, technology spillover, monopoly effects, and so on. Therefore, hypothesis 3 is valid. Table 3, column (3), column (6) of the regression results show that the proportion of overseas patent applications in developed countries and the number of exports, export quality, there is an 'inverted U-shaped' relationship, and the inflection point of about 0.54, respectively, 0.59; overseas patent applications in developed countries in the proportion of the mean value of 0.73. This shows that whether it is related to the quantity of export or the quality of export, the proportion of overseas patent applications in developed countries is located on the right side of the inflection point, and it is not conducive to the promotion of domestic exports to continue to increase the layout of overseas patent applications in developed countries, which indicates that the layout of overseas patents in developed countries in many countries is excessive and may inhibit the strategy of the layout of overseas patents in developed countries due to the increase in costs, fierce competition and other reasons, which again confirms the empirical results in Table 2.

Table 3 Non-Linear Relationship between Overseas Patent Network Layout and Export Quantity and Export Quality

Variable	Export Quantity			Export quality		
	(1)	(2)	(3)	(4)	(5)	(6)
Cons	36.795*** (6.496)	46.024*** (5.455)	64.416*** (11.557)	16131.710*** (618.648)	23538.850*** (837.239)	16531.840*** (642.635)
GD	-0.745*** (0.187)			135.895*** (13.040)		
GD^2	0.043*** (0.003)			-0.384*** (0.119)		
SD		0.814*** (0.027)			7.878*** (0.982)	
SD^2		-0.00022*** (0.00001)			-0.003*** (0.0004)	
PDC			499.942*** (51.180)			33883.000*** (3069.449)
PDC^2			-462.281*** (49.234)			-28951.060*** (2636.917)
RES	0.9632*** (0.0744)	0.8229*** (0.0633)	0.2131 (0.1298)	37.2968*** (7.8983)	13.1423 (9.5951)	9.0393 (10.5764)
FDI	-0.8645*** (0.2425)	-0.8958*** (0.2356)	-1.6072*** (0.4489)	23.3366** (10.1215)	-2.6879 (6.2181)	-10.3180 (6.4108)
EDUE	-3.1550*** (0.4391)	-2.5572*** (0.3291)	-7.4339*** (0.8042)	-55.0232*** (20.7203)	-246.9012*** (23.1926)	-338.5320*** (28.6551)
TE	2.2102***(0.2301)	1.8445*** (0.1863)	2.4626*** (0.2270)	127.5635*** (7.7105)	118.8433*** (8.3900)	135.2535*** (9.7817)
OFDI	0.6714*** (0.1737)	0.7745*** (0.1287)	1.1649*** (0.2663)	-16.2471* (9.3891)	14.7295*** (5.6594)	16.3903** (7.2295)
Country & year	yes	yes	yes	yes	yes	yes
R2	0.6043	0.5820	0.3241	0.5892	0.3316	0.3408

F	172.3837***	157.1073***	54.1178***	161.8405***	55.9846***	58.3341***
N	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

4.4 Endogeneity and robustness analysis

4.4.1 Endogeneity test

The four indicators of overseas patent layout may not be strictly exogenous, and it is difficult to exclude the existence of endogeneity problems such as omitted variables. The lag one period of the endogenous variable has a strong correlation with the endogenous variable and no significant correlation with the error term, which meets the conditions of the existence of a significant correlation between the instrumental variable and the endogenous variable and the exogeneity of the instrumental variable, and it is considered to be a valid instrumental variable[43], so this paper adopts the lag one period of the breadth, depth, and quality variables of the overseas patent network as the instrumental variable respectively Endogeneity regression was conducted, and the specific results are shown in Table 4.

For the impact of overseas patent layout on the number of exports, the instrumental variable regression results after considering endogeneity show that the coefficients of the impact of the breadth and depth of overseas patent network and the share of patent applications for inventions filed overseas on the number of exports are still robustly positive, and the absolute values of the coefficients of the breadth and the share of patent applications filed for inventions filed overseas have increased compared with those of the baseline regression, which suggests that the positive impact of the breadth of overseas patent network and the share of patent applications for inventions filed overseas on the number of exports may be underestimated if endogeneity issues are not controlled. In addition, for the effect of overseas patent layout on export quality, after considering the endogeneity problem, the instrumental regression results show that the results of overseas patent network breadth, depth and the share of overseas invention patent applications on export quality are still robustly positive, but the effect values of overseas patent network breadth and depth have decreased compared with the baseline regression, and the effect value of the share of overseas invention patents has increased.

Table 4 One Period Lagged Instrumental Variables Regression

Variable	Export Quantity				Export quality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cons	-70.744*** (11.215)	84.749*** (8.275)	88.176*** (34.3007)	187.997* (98.73)	17817.95*** (791.291)	24859.14*** (753.055)	23768.47*** (779.879)	23512.88*** (1040.710)
GD	4.222*** (0.350)				89.896*** (6.309)			
SD		0.300*** (0.011)				1.765***(0.238)		
IPP			108.310*** (28.979)				3012.061*** (419.365)	
PDC				38.533 (72.06)				1213.515 (897.237)
RES	0.9568*** (0.1254)	0.6441*** (0.074)	0.2338 (0.4285)	0.1281 (0.558)	32.7806*** (8.7473)	9.0489 (10.7993)	1.0778 (9.9768)	6.4941 (9.6754)
FDI	-0.7874** (0.3434)	-1.294*** (0.338)	-1.3505*** (0.303)	-2.1004** (0.831)	17.9907* (9.31)	-10.3479* (5.5259)	-8.8316 (5.5434)	-12.0182*** (4.6173)
EDUE	-1.7403*** (0.4635)	-3.65*** (0.348)	-7.4023*** (1.963)	-9.6195** (4.012)	-96.1451*** (17.6589)	-308.746*** (21.5937)	-354.247*** (25.9801)	-256.178*** (31.8120)
TE	2.4851(0.3088)	2.4621*** (0.255)	2.8613*** (0.4668)	2.3999** (1.194)	133.6369*** (6.1877)	134.5443*** (7.2377)	130.9423*** (6.3959)	136.5868*** (12.6129)
OFDI	0.3094 (0.2348)	1.0309** (0.19)	1.0083*** (0.2973)	2.0841** (1.036)	-10.6599 (8.9942)	18.6651*** (5.8063)	18.7072*** (6.1825)	21.3055*** (5.2754)
Country &	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.7881	0.4931	0.2351	0.0840	0.5883	0.2859	0.2796	0.1872
F	465.49***	121.77*** 	38.4725*** 	11.479*** 	178.8309*** 	50.1029***	48.5892***	28.8243***

N	758	758	758	758	758	758	758	758

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

4.4.2 Robustness test

Considering the impact of other factors on the regression estimation results of this paper, we will further conduct a robustness test of the empirical model. The three ways of testing are considered in the robustness test: lagging the explanatory variables by one period, replacing the explanatory variables and replacing the explanatory variables, and the results are shown in Tables 5-7 below.

Firstly, the method of regressing the lagged one period of the explanatory variables using the quantity of exports and the quality of exports respectively. By comparing the results of the benchmark regression (Table 2) with the results of the lagged one-period regression (Table 5), it can be found that the effects of the breadth and depth of the overseas patent network and the proportion of patent applications for inventions abroad on the quantity and quality of exports are basically the same as those above, i.e., the breadth and depth of the overseas patent network and the proportion of patent applications for inventions abroad have a promotional effect on the quantity and quality of exports.

Variable	Export Quantity				Export quality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cons	-64.553*** (13.923)	83.678***	104.749***	177.237***	18466.79***	24792.43***	24071.83***	26100.69***
GD(-1)	4.160*** (0.366)				84.635*** (5.955)			
SD(-1)		0.310*** (0.011)				1.905*** (0.270)		
IPP(-1)			86.903*** (12.696)				2636.138***	
PDC(-1)				-21.900 (16.880)				-589.873 (900.386)
RES	1.0032*** (0.113)	0.6439*** (0.072)	0.2296 (0.1468)	0.2134* (0.1137)	30.2253*** (8.8372)	9.1209 (10.7983)	1.4214 (10.1769)	5.9033 (6.7272)
FDI	-0.865** (0.364)	-1.292*** (0.335)	-1.4124*** (0.4699)	-1.7629 (0.3107)	11.3330 (7.1986)	-10.1517* (5.5609)	-5.7230 (5.8054)	-14.9078 (11.1857)
EDUE	-1.796*** (0.477)	-3.594*** (0.357)	-7.4199*** (0.7290)	-6.5745*** (0.6166)	-112.786*** (18.9619)	-305.228*** (21.5447)	-356.228*** (25.2582)	-352.42*** (29.2681)
TE	2.5486***(0.297)	2.4705*** (0.258)	2.8579*** (0.2481)	2.8122*** (0.2118)	134.2523*** (5.2956)	134.5477*** (7.2580)	129.452*** (7.0275)	139.2781*** (10.5696)
OFDI	0.4630** (0.233)	1.0374*** (0.189)	1.0480*** (0.2694)	1.2401*** (0.3106)	-2.1211 (6.2349)	18.5591*** (5.7812)	15.2671*** (5.8862)	21.0114** (10.0545)
Country	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.7805	0.5009	0.2292	0.3116	0.5493	0.2896	0.2800	0.2681
F	445.04***	125.61***	37.2238***	56.6426***	152.5748***	51.0351***	48.6794***	45.8497***
N	758	758	758	758	758	758	758	758

Table 5 Lagged One Period Regression Test Results

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

Secondly, this paper uses the replacement of core explanatory variables to carry out the robustness test. Replacing the application layout of overseas patents with the granting of overseas patents for regression, the results are shown in Table 6. The results show that the breadth (GDA) and depth (SDA) of overseas granted patents and the proportion of overseas invention granted patents (IPAP) have a significant positive effect on the quantity and quality of exports, and the proportion of overseas patents granted in developed countries (PADC) has no significant effect on the quality of exports, which is consistent with the above regression results and test results. However, the significance level of the proportion of overseas patents granted in developed countries on the role of export quantity has changed, and the proportion of overseas patents granted in developed countries has a significant positive effect on export quantity, which means that

the more the proportion of overseas patents granted in developed countries, the higher the quality of the overseas patent layout, and the greater the promotion effect on export quantity.

Table 6 Results of Regression Test for Replacement of Explanatory Variables

Variable	Export Quantity				Export quality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cons	-56.810*** (10.711)	77.039*** (8.227)	102.504*** (12.379)	169.81*** (26.57)	17764.94*** (745.538)	24270.39*** (422.526)	23743.01*** (887.820)	23905.01*** (686.288)
GDA	4.126*** (0.318)				90.122*** (5.304)			
SDA		0.522*** (0.016)				3.707***(0.567)		
IPAP			70.953*** (11.817)				2951.665*** (664.423)	
PADC				59.219*** (20.62)				249.348 (808.317)
RES	0.9949*** (0.1063)	0.7215*** (0.0643)	0.2770** (0.1365)	0.1433 (0.133)	35.8628*** (8.1424)	13.0030* (6.8442)	0.6789 (10.2966)	6.5984 (8.7008)
FDI	-0.798*** (0.2902)	-1.246*** (0.3166)	-1.4692*** (0.4681)	-2.09*** (0.609)	19.7770* (10.5691)	-8.3962 (10.8623)	-5.5066 (6.1316)	-11.0713 (10.0331)
EDUE	-0.6799* (0.4084)	-3.332*** (0.3570)	-6.1196*** (0.7439)	-9.026*** (1.451)	-73.1860*** (20.2550)	-282.66*** (29.8270)	-319.858*** (31.2893)	-245.167*** (35.6691)
TE	2.0340***(0.2402)	2.2765*** (0.2400)	2.8183*** (0.2364)	2.2741*** (0.288)	125.8141*** (7.3187)	126.0110*** (10.3916)	119.2952*** (7.0180)	131.3269*** (14.0874)
OFDI	0.4344** (0.1930)	1.0344*** (0.169)	1.1097*** (0.2690)	2.0899*** (0.404)	-10.5659 (9.8120)	18.5331*** (9.7115)	16.4989*** (6.2574)	21.5255** (10.0556)
Country &	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.7691	0.5031	0.2181	0.0865	0.5540	0.2631	0.2738	0.1755
F	439.11***	133.462***	36.7719***	12.482***	163.7798***	47.0679***	49.7082***	28.0588***
N	798	798	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

Finally, this paper uses a country's position in the division of labor in the global value chain as a proxy indicator of a country's export quality to conduct a regression [44], and the results of the study indirectly verify the stability of the basic regression and the non-linear model, and the results are shown in Table 7. Columns (1)-Column (4) of Table 7 are the regressions of global value chain division of labor position on the four indicators of overseas patent network layout, and Columns (5) - (7) of Table 7 are the regressions of global value chain division of labor position on the three indicators of overseas patent layout and their quadratic terms, respectively. The results show that the effects of overseas patent network breadth, depth, the proportion of overseas invention patent applications and the proportion of overseas patent applications in developed countries on GVC embedding are all significantly positive; there is a 'U' shaped relationship between the breadth of overseas patent network and the location of the division of labor in GVCs. Depth and the proportion of overseas patent applications in developed countries have an 'inverted U-shaped' relationship with the location of global value chain division of labor, which is basically consistent with the conclusions of the benchmark regression and the non-linear model, which also indicate that the empirical results of this paper have a strong robustness.

Table 7 Results of Regression Test for Replacement of Explanatory Variables

Variable	position in global value chains						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Cons	-0.109*** (0.008)	-0.082*** (0.006)	-0.088*** (0.010)	-0.102*** (0.007)	-0.088*** (0.007)	-0.093*** (0.007)	-0.125*** (0.011)
GD	0.001*** (0.0001)				-0.000017 (0.0003)		
GD^2					0.000007*** (0.000002)		
SD		0.0001*** (0.000005)				0.00016*** (0.000008)	
SD^2						0.00000003*** (0.000000003)	
IPP			0.061*** (0.010)				
PDC				0.074*** (0.011)			0.169*** (0.038)
PDC^2							-0.085*** (0.029)
RES	0.0044*** (0.0001)	0.0042*** (0.0001)	0.0040*** (0.0001)	0.0042*** (0.0001)	0.0044*** (0.0001)	0.0043*** (0.0001)	0.0042*** (0.00008)
FDI	-0.0021*** (0.0006)	-0.0024*** (0.0006)	-0.0024*** (0.0007)	-0.0023*** (0.0006)	-0.0023*** (0.0006)	-0.0023*** (0.0005)	-0.0023*** (0.0006)
EDUE	-0.0016*** (0.0004)	-0.0015*** (0.0004)	-0.0032*** (0.0003)	-0.0033*** (0.0003)	-0.0021*** (0.0004)	-0.0012*** (0.0004)	-0.0032*** (0.0003)
TE	-0.0012***(0.0001)	-0.0015*** (0.0001)	-0.0013*** (0.0001)	-0.0012*** (0.0001)	-0.0013***(0.00009)	-0.0016*** (0.0001)	-0.0012*** (0.0001)
OFDI	0.0017*** (0.0005)	0.0020*** (0.0005)	0.0020*** (0.0005)	0.0019*** (0.0005)	0.0019*** (0.0005)	0.0018*** (0.0004)	0.0019*** (0.0005)
Country & year	yes	yes	yes	yes	yes	yes	yes
R2	0.8319	0.8470	0.8183	0.8195	0.8354	0.8509	0.8289
F	652.388***	729.9184***	593.651***	598.44***	572.6768***	644.1610***	546.737***
N	798	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

4.5 Heterogeneity analysis

4.5.1 Heterogeneity analysis of different country types

In order to examine the differences in the effect of overseas patent network layout on exports in different economies, this paper sets up a country dummy variable dc with reference to the World Bank's classification criteria for developed and developing countries, with dc=1 for developed countries and dc=0 for developing countries. In Table 8, columns (1) - (4) show the regression results of the quantity of exports on the layout of overseas patent network, and columns (5) - (8) show the regression results of the regression results of export quality on overseas patent network layout. As can be seen from the table, the export effects of the breadth and depth of overseas patent networks and the share of overseas invention patent applications vary significantly across economies. Column (1) and (3) show that the overseas patent network breadth, quality variables and their interaction terms with country dummy variables can pass the 1% significance level test and the direction of the coefficients is positive, which indicates that the level of national economic development plays a positive role in the impact of the breadth of overseas patent networks and the share of overseas invention patent applications on the number of exports, i.e., for developed countries, the positive impact of the breadth of overseas patent networks and the share of overseas invention patent applications on the number of exports is more pronounced, possibly because developed countries' overseas patent networks are more mature, and their marginal costs of expanding their overseas patent networks are smaller and more beneficial. From Column (2) and Column (4), the coefficients of the depth of overseas patent network and the share of layout in developed countries are positive, and the coefficients of the interaction terms are both negative, which both pass the test of significance level of 1%, which suggests that the effect of the depth of overseas patent network on the number of exports is greater in developing countries than in developed countries, i.e. for developing countries, the depth of overseas patent network and the proportion of layout in developed countries have a stronger effect on the number of exports, probably because the construction of overseas patent network of most developing countries is still in the primary stage, and the export effect of the depth of patent network is still in the stage of marginal increment, while on the contrary, the developed countries have experienced a marginal decreasing or even a negative effect in some markets. Similarly, as shown in Columns (5)-(8), the positive impacts of the breadth and depth of overseas patent networks and the proportion of layouts in developed countries on the quality of exports of developing countries are significantly higher than those on developed

countries, while the impacts of the proportion of overseas invention patent applications on the quality of exports of the two types of economies are not significantly different. To sum up, compared with developing countries, the breadth of overseas patent networks and the proportion of overseas invention patent applications in developed countries have a greater impact on the quantity of exports; compared with developed countries, the depth of overseas patent networks and the proportion of layouts in developed countries in developing countries have a stronger contribution to the quantity and quality of exports, and the breadth of overseas patent networks has a stronger effect on the quality of exports. This also confirms the paths and trends of overseas patent network layout in different economies: developed countries are more inclined to expand overseas patent markets and upgrade their patent technology level in order to expand the scale of exports, while developing countries are comprehensively strengthening their overseas patent layout in order to improve the comprehensive competitiveness of their exports.

Table 8 Analysis of Variability Across Country Typologies

Variable	Export Quantity				Export quality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cons	6.7905 (6.9024)	43.592***	61.898***	72.969*** (15.815)	13345.90***	18417.33***	18273.020***	16218.91***
DC	-80.158*** (13.065)	30.798** (3.121)	-33.230**	259.221***	4046.780***	4366.979***	4924.455*** (583.757)	16894.78***
GD	2.123 *** (0.141)				115.337*** (9.832)			
SD		1.530*** (0.167)				21.221*** (6.599)		
IPP			53.355* (8.879)				1989.768*** (713.924)	
PDC				32.216*** (10.617)				4472.005***
*DC*GD*	2.0141*** (0.311)				-40.382*** (9.948)			
*DC*SD*		-1.237*** (0.162)				-19.624*** (6.437)		
*DC*IPP*			102.205**				-1292.688 (792.626)	
*DC*PDC*				-284.945*** (41.5154)				-17101.78*** (2208.99)
RES	0.8309 *** (0.0893)	0.5805** (0.0743)	0.2696*** (0.1326)	0.4971*** (0.1059)	57.2222*** (8.1152)	43.1450*** (8.9885)	37.3210 *** (8.7503)	50.1351*** (9.2139)
FDI	-0.641*** (0.2466)	-1.158*** (0.302)	-1.2183*** (0.3509)	-1.7532*** (0.4815)	11.8079 (7.4002)	-7.6082 (5.3148)	-8.9109* (5.1554)	-10.8603 (7.8348)
EDUE	-2.8130*** (0.5475)	-2.506*** (0.3217)	-3.8604*** (0.6457)	-4.2310*** (0.6264)	35.8305* (19.8732)	-75.6914*** (18.2012)	-119.346*** (20.3335)	-129.854*** (22.5219)
TE	2.3929***(0.2336)	2.0575*** (0.2560)	1.9710 (0.2272)	2.2297*** (0.2845)	118.8535*** (7.2448)	105.2595*** (6.3177)	107.7382*** (5.9106)	116.6155*** (7.6069)
OFDI	0.3721** (0.1657)	0.9720*** (0.159)	1.0032*** (0.1886)	1.3261*** (0.2672)	-10.9933 (7.5820)	8.9936** (4.5782)	9.4459** (4.5660)	0.9089* (6.4955)
Country & year	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.6353	0.5046	0.2443	0.2861	0.6621	0.3998	0.3757	0.4358
F	171.769***	100.45***	31.888***	39.521***	193.220***	65.708***	59.352***	76.191***
N	798	798	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

4.5.2 Analysis of the differential impact of different patent types

In order to test the differential impact of different types of overseas patent network layout on exports, we categorize overseas patents into three types: invention patents, utility model patents and design patents, and examine the impact of the breadth and depth of their network layouts on the quantity and quality of a country's exports respectively. Table 9 shows the regression results of the impact of different patent network breadth on export quantity and export quality, and Table 10 shows the regression results of the impact of different patent network depth on export quantity and quality.

In terms of overseas patent network breadth, as shown in Table 9, the coefficients of overseas invention patent network

breadth (IGD), utility model patent network breadth (UGD), and design patent network breadth (DGD) are all positive, and they all pass the significance level test of 1 percent, suggesting that all three types of overseas patent network breadth are positively correlated with the quantity and quality of exports. The results from the number of exports show that the estimated coefficient of the utility model patent network breadth variable is the largest, followed by invention patents and finally design patents. This indicates that overseas utility model patent network breadth has the greatest contribution to export quantity and overseas design patent network breadth has the least contribution to export quantity. The results for export quality show that overseas utility model patent network breadth has the largest positive impact on export quality, and design patent network breadth has the smallest positive impact on export quality, and that there is a large difference in the marginal increment in export quality between the two. The possible reasons for this are that utility model patents are more applicable and economical in overseas markets, and are more conducive to promoting productivity and innovation levels, thus improving export quantity and quality; design patents are mainly used to solve problems such as patent litigations and disputes in overseas markets, and provide legal and regulatory protection for home market entities to enter the host country's market, and thus are more conducive to the growth of export scale, and have less impact on export. The layout of invention patents in different overseas markets can make full use of the resources of different host country markets, reduce marginal costs, expand the scale of exports, and obtain a favorable competitive position through technological advantages, thus improving the quality of exports.

Table 9 Differential Analysis of the Breadth of Different Patent Types

Variable	Export Quantity			Export quality		
	(1)	(2)	(3)	(4)	(5)	(6)
Cons	-41.142***	19.220***	1.446	17203.280***	19828.750***	19906.240***
	(6.855)	(5.603)	(5.557)	(470.347)	(422.047)	(450.355)
IGD	4.529***			130.233***		
	(0.232)			(5.042)		
UGD		11.130***			304.242***	
		(0.499)			(12.788)	
DGD			3.933***			88.885***
			(0.153)			(4.061)
RES	0.4987***	0.5909***	1.2101***	28.8751***	16.7406***	33.8453***
	(0.1059)	(0.0900)	(0.0874)	(5.9241)	(5.9903)	(6.4335)
FDI	-0.4894**	-0.4535***	-0.9204***	22.9052***	17.5704*	13.2543
	(0.2184)	(0.1261)	(0.2664)	(8.8350)	(9.3423)	(9.1708)
EDUE	-0.7941	-1.7211***	-2.4386***	-75.6093***	-106.267***	-147.0626***
	(0.5273)	(0.4847)	(0.4388)	(26.0762)	(27.8492)	(27.8757)
TE	1.5216***	1.8296***	2.0134***	126.8925***	126.0063***	126.8215***
	(0.1810)	(0.1823)	(0.1992)	(8.4398)	(9.5037)	(9.3054)
OFDI	0.2615**	0.3634***	0.7704***	-12.6601	-10.2132	-3.1514
	(0.1810)	(0.0960)	(0.2118)	(8.0133)	(8.6289)	(8.5766)
Country & year	yes	yes	yes	yes	yes	yes
R^2	0.5920	0.5846	0.5423	0.5813	0.5527	0.5145
F	191.318***	185.548***	156.206***	183.035***	162.897***	139.710***
N	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

In terms of overseas patent network depth, as shown in Table 10, the coefficients of overseas invention patent network depth (ISD), utility model patent network depth (USD) and design patent network depth (DSD) are all positive and pass the 1% significance level test, indicating that all three types of overseas patent network depth are positively related to export quantity and quality. The results in Columns (1)-(3) show that the design patent network depth has the greatest contribution to the quantity of exports, followed by utility model patents, and the invention patent network depth has the least contribution to the quantity of exports. Columns (4)-(6) show that the depth of network of utility model patents has the largest contribution to the quantity of exports, followed by design patents, and the depth of network of invention patents has the smallest contribution to the quality of exports. Analyzing the reasons, compared with utility model patents and appearance patents, invention patents have the highest degree of innovation, and multiple layouts of invention patents in the same overseas market make the resources too concentrated in the host market, causing technological embargoes in the host market, and weakening the motivation to innovate of the market main body, which is unfavorable to the enhancement of the quality of exports. In addition, excessive placement of patents on overseas inventions may create market monopolies, leading to increased intervention and regulation by the host government, thus inhibiting the growth of the number of exports from the home country. Appearance patents are the least innovative and are less subject to host government intervention due to greater depth of layout. A greater depth of patents on the exterior

means that the home country is better able to understand the market environment of the host country and to integrate and use local resources, which leads to lower transaction costs and stimulates export behavior and investment in technological innovation.

Table 10 Differential Analysis of the Depth of Different Patent Types

Variable	Export Quantity			Export quality		
	(1)	(2)	(3)	(4)	(5)	(6)
Cons	78.509***	84.751***	44.165***	24373.870***	24431.130***	23408.070***
	(8.000)	(8.773)	(5.316)	(788.948)	(766.584)	(824.889)
ISD	0.300***			1.940***		
	(0.012)			(0.236)		
USD		2.283***			27.693***	
		(0.723)			(4.460)	
DSD			2.878***			25.711***
			(0.1171)			(2.932)
RES	0.6876***	0.6244***	0.8206***	12.4662	12.9907	16.9818*
	(0.0663)	(0.0776)	(0.0734)	(9.7919)	(9.6522)	(9.9789)
FDI	-1.2372***	-1.3135***	-0.8843***	-8.3950	-8.6569	-3.4986
	(0.3217)	(0.3929)	(0.1729)	(5.7811)	(5.8052)	(5.9204)
EDUE	-3.3544***	-3.8622***	-2.4504***	-286.368***	-295.582***	-246.874***
	(0.3434)	(0.4389)	(0.3073)	(23.0220)	(24.5843)	(23.5494)
TE	2.2488***	2.6693***	1.9453***	124.9191***	126.7544***	123.1263***
	(0.2433)	(0.2550)	(0.1607)	(8.3706)	(7.6317)	(8.5441)
OFDI	1.0182***	0.9447***	0.8942***	18.5298***	17.9170***	14.8539***
	(0.1748)	(0.2404)	(0.1866)	(5.9469)	(6.0162)	(5.3439)
Country & year	yes	yes	yes	yes	yes	yes
R^2	0.4982	0.3017	0.5655	0.2616	0.2722	0.3025
F	130.892***	56.9535***	171.568***	46.709***	49.299***	57.179***
N	798	798	798	798	798	798

Note: *, ** and *** are significance levels of 10%, 5% and 1%, respectively, with standard errors in parentheses.

5 CONCLUSIONS AND RECOMMENDATIONS

Using overseas patent data from 60 countries from 2000 to 2018, this paper empirically examines the dual influence effect and mechanism of overseas patent network layout on a country's export quantity and export quality from the multi-dimensional aspects of overseas patent network breadth, depth and quality. It is found that: (1) The breadth and depth of overseas patent networks and the proportion of overseas invention patent applications have a significant positive impact on the quantity and quality of a country's exports, while the proportion of patent layouts in developed countries has a significant negative impact on the quantity of a country's exports, and a non-significant impact on the quality of exports. (2) The role of the breadth of overseas patent network on the quantity of a country's exports shows a 'U-shaped' relationship, and the role of the quality of a country's exports shows an 'inverted U-shaped' relationship. The depth of overseas patent network and the proportion of patent layout in developed countries show an 'inverted U-shaped' relationship for both the quantity and quality of a country's exports. (3) Analyses of the heterogeneity of patent applicant countries show that the export effect of overseas patent networks varies across economies. For developed countries, expanding overseas patent layout markets and upgrading the level of patented technology can lead to a larger scale of exports. For developing countries, increasing the depth of patent layout and patent layout in developed countries is more conducive to expanding the scale of exports, and improving the breadth and depth of overseas patent networks and patent layout in developed countries is more conducive to improving the quality of exports. (4) After considering the differences in patent types, it is found that the breadth of the utility model patent network and the depth of the design patent network have a stronger positive impact on the quantity and quality of exports, and the marginal utility brought about by the increase in the depth of the invention patent network is lower.

A country's overseas patent applications are not the more the better, and a reasonable overseas patent network layout and structure can bring higher export performance. The main policy implications of this paper are: (1) Encourage international patent applications and technology mergers and acquisitions, reasonably strengthen the diversification of the host country's market, form the networked and scaled advantages of overseas patent layout, and realize the superposition of the positive effects of the breadth of the patent layout on the quantity and quality of exports. (2) Strengthening cooperation with local institutions in host countries, guiding enterprises to operate continuously in the same host country market, improving the degree of embeddedness and quality level of overseas patent network, accumulating independent intellectual property rights continuously, and obtaining competitive advantages in export. (3)

Reasonably dispersing resources and carrying out overseas patent layout in countries with emerging economies such as 'the Belt and Road', so as to reduce costs and market competition pressure, and thus improve export performance. (4) Choose different patent layout paths and strategies according to the country's level of development and objectives, and pay attention to the differences in the impact of different types of patent layout, so as to obtain greater marginal gains and long-term enhancement of a country's international competitiveness.

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DIFFERENCES IN HAPPINESS OF CONSUMPTION TYPES IN SOCIAL SCENES FROM THE PERSPECTIVE OF SYMBOLIC INTERACTION: THEORETICAL DEBATE AND INTEGRATION OF SYMBOLIC CONSUMPTION AND EXPERIENTIAL CONSUMPTION

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Abstract: In the context of consumption upgrade, happiness has become a core issue in consumer behavior research. Existing studies emphasize the positive effects of experiential consumption on happiness but overlook the value of symbolic consumption in identity construction and social recognition through symbolic transmission, and lack an examination of the dynamics of real social scenarios. This paper, based on symbolic interactionism, integrates perspectives from psychology, sociology, and marketing to compare the mechanisms by which symbolic consumption and experiential consumption affect happiness, revealing the moderating effects of social scenarios, cultural norms, and individual traits. The study finds that symbolic consumption achieves a "silent declaration of identity" through the visibility of material symbols (such as luxury goods), but its happiness is easily constrained by "vanity stigma" and cultural norms; experiential consumption relies on narrative sharing and emotional resonance, offering advantages in high-social-interaction settings, yet it is limited by individual expression capabilities and opportunities for sharing. The effects of these two types of consumption are complementary in online-offline integrated scenarios, with cultural differences (such as collectivism versus individualism) and self-construction types (independent versus dependent) further moderating their happiness output. The study calls for attention to the complexity of symbolic interactions in consumer behavior and proposes a three-dimensional integrated model of "consumption type—symbolic interaction—happiness," providing a theoretical framework for future exploration of virtual-real integration scenarios, deepening the classification of symbolic consumption, and optimizing paradigms for measuring happiness.
Keywords: Symbolic interactionism; Symbolic consumption; Experiential consumption; Happiness

1 INTRODUCTION

1.1 Definition of core concepts

1.1.1 Symbolic consumption

Symbolic consumption refers to the act of consumers conveying symbolic information such as identity, status, and values through the purchase and use of goods or services with specific social significance [1]. For example, luxury items, branded clothing, or limited-edition products not only meet functional needs but also serve as tools for representing social identity. The core characteristic lies in the symbolic value carried by these goods (such as social recognition and class distinction), rather than their mere utility.

1.1.2 Experience consumption

Experiential consumption refers to consumer behavior oriented towards fulfilling emotional, memory, or spiritual needs, with its value stemming from the subjective experience during participation (such as travel, concerts, course learning) [2]. Unlike symbolic consumption, the core of experiential consumption lies in satisfying intrinsic motivations (such as personal growth, social connections), and reinforcing its social value through narrative sharing (such as travel stories) [3].

1.1.3 Happiness

Happiness in consumption research usually includes two dimensions of subjective happiness (life satisfaction, positive emotion) and social happiness (sense of belonging, social identity) [4]. Its formation not only depends on the satisfaction of personal needs, but also is influenced by the feedback of others in social interaction.

1.1.4 Symbolic interaction characteristics of social scenes

In social scenarios, consumer behavior is essentially a process of symbolic interaction: Identity Display: conveying self-concepts (such as "who I am") through consumption symbols (like brands, behaviors); Social Recognition; interpretations of these symbols form social evaluations of consumers (such as respect, jealousy); Dynamic Negotiation: the meaning of symbols is reconstructed in response to changing interactive contexts (online/offline) and cultural backgrounds (collectivism/individualism).

2 THEORETICAL DIVERGENCE BETWEEN CONSUMPTION TYPES AND HAPPINESS

2.1 Consensus on the advantages of experiential consumption

There is a broad consensus on the positive impact of experience consumption on happiness, and its mechanism can be unfolded from the following dimensions:

2.1.1 Satisfaction of intrinsic motivation

Based on self-determination theory [5], experiential consumption stimulates lasting happiness by satisfying three psychological needs: autonomy (such as free exploration during travel), competence (such as the sense of achievement in learning new skills), and belonging (such as spending time with friends and family)[6].

Emotional connection effect: Experiential consumption is often accompanied by strong emotional memories (such as wedding, graduation trip), and through the time discounting effect , its positive emotions are continuously strengthened over time [7].

2.1.2 High conversation value and social sharing effect

Conversation Value: Experiential consumption, due to its narrative nature (such as "I saw the aurora at the South Pole"), naturally serves as a social topic, facilitating interpersonal interaction [8]. Studies show that participants who share their experiences of experiential consumption are more likely to be perceived as "interesting" and "trustworthy" by others [3].

Social bonding enhancement: Sharing behaviors in experiential consumption can trigger empathetic responses (such as emotional resonance in listeners), thereby strengthening consumers' sense of social belonging [2]. For example, participants in concerts who shared live videos on social media experienced significantly greater increases in happiness compared to those who did not share [9].

2.2 Controversy of Symbolic Consumption

There are significant theoretical differences on the impact of symbolic consumption on happiness, and the core of the controversy lies in the "double-edged sword effect" of symbolic value:

2.2.1 Positive propositions of symbolic value theory

Identity construction tools: Belk proposed the theory of "extended self", which believed that symbolic consumption (such as wearing a Rolex watch) helped consumers to construct social identity (such as "successful people") through the materialization of identity symbols (materialized identity), so as to enhance self-esteem and social identity[10].

Class segregation function: Bourdieu's "cultural capital" theory points out that luxury goods or niche cultural symbols (such as limited edition sneakers) can be used as class markers, which strengthen the sense of belonging within the group through symbolic exclusion and indirectly improve happiness.

2.2.2 Critical view: the trap of materialistic happiness

The negative impact of materialism: Kasser's empirical research shows that consumers who overly rely on material symbols to define their self-worth (such as "gaining recognition from others through luxury goods") have lower subjective well-being. This tendency is closely related to social comparison anxiety (such as "others have more than me") and goal alienation (such as "being in debt for symbolic consumption").

2.2.3 Social risks and stigmatization

Showy Stigmatization: In collectivist culture, the explicit display of symbolic consumption (such as luxury cars) is easily seen as "showy", which can lead to jealousy or negative evaluation from others and weaken consumers&039; social happiness [11].

Symbolic rigidity: The symbolic meaning of symbolic consumption is scene-dependent. For example, wearing a famous watch in the workplace may convey a "professional" image, but it may be regarded as "out of place" in public welfare activities, leading to identity conflict[12].

3 THE EXPLANATORY PATH OF SYMBOLIC INTERACTIONISM

3.1 Symbolic Transmission Mechanism

Symbolic interactionism holds that consumption behavior is essentially a process of the production and exchange of symbolic meanings . Consumers convey their self-concept and social identity to others by selecting specific goods or services, while receivers interpret and respond to these choices based on the symbolic meanings. There are significant differences in the symbolic transmission mechanisms of the two types of consumption:

3.1.1 Symbolic consumption: silent declaration of identity

The Directness of Symbols: Symbolic consumption (such as luxury goods, famous cars, limited-edition sneakers) achieves immediate identity transmission through the visibility of material symbols (such as brand logos, unique designs). For example, wearing a Rolex watch requires no verbal explanation; its symbolic value (wealth, success) has been solidified in social consensus, forming a "silent declaration of identity" .

Stability and class segregation of symbols: Such symbols are often bound to specific social classes , and their meanings

are institutionalized in long-term cultural practices. For example, Hermes platinum bag is not only a luxury product, but also regarded as an identity symbol of "elite class", whose symbolic meaning has low interpretation ambiguity.

3.1.2 Experiential consumption: narrative social dependence

The necessity of language sharing: The symbolic value of experience consumption (such as travel, concerts) needs to be conveyed through narrative language. For example, consumers need to actively describe "the experience of chasing the aurora in Iceland" so that others can understand the meaning behind it (such as the spirit of adventure, aesthetic taste) [13].

Limitations of social opportunities:

Sharing threshold: The symbolic transmission of experience consumption depends on the opportunity of dialogue in social scenes. If there is no opportunity to share (such as the solitary person has no social object), its symbolic value may not be fully realized[3].

Differences in narrative ability: Individuals' expression skills affect the effect of symbolic transmission. Those who are not good at speaking may be unable to effectively convey the deep meaning of experience, which weakens the happiness effect [8].

3.2 The Moderating Effect of Social Scenarios

The social scene significantly moderates the happiness effect of the two types of consumption through the difference of symbolic visibility and interaction opportunities:

3.2.1 No sharing scenario: the symbolic visibility of consumption is dominant

Passive Display of Symbols: In scenarios lacking opportunities for active sharing (such as daily commuting and public settings), visible symbols of symbolic consumption (like wearing luxury brands) can still convey identity information through non-verbal interactions. For example, wearing a high-end watch in the workplace can silently communicate professionalism and economic strength without verbal explanation .

Low interaction cost: In this kind of scenario, the symbolic transmission efficiency of symbolic consumption is higher because it depends on the persistence of material carriers (such as clothing and accessories are always visible), while experiential consumption depends on the chance of occasional dialogue.

3.2.2 High sharing scenario: the narrative advantage of experience consumption is highlighted

Empathy Connection Reinforcement: In social-dense settings (such as friend gatherings, social media), sharing narratives about experiential consumption can trigger empathetic responses from listeners, fostering emotional resonance. For example, recounting the experience of "hiking alone in Tibet" might elicit admiration for courage and freedom, enhancing consumers' sense of social identity[2].

Accumulation of social capital: Experiential consumption stories are more likely to be forwarded or liked, and then converted into digital social capital (such as weibo likes and circle of friends interaction). Studies show that users who share experiential consumption on social media have a 1.5 times increase in happiness compared with those who share symbolic consumption [9].

3.2.3 Scene hybridity: symbolic interaction between online and offline

The complementarity of online visibility and offline narrative: for example, after consumers buy trendy clothing (symbolic consumption), they post photos of their outfits on social media (online symbol display), and tell the brand story in offline parties (experiential narrative), forming cross-scene symbol reinforcement.

Online scenes may amplify the risk of "showing off" symbolic consumption (such as negative comments from anonymous users); the narrative of experiential consumption can reduce language dependence and expand the scope of symbol transmission through visual expression on short video platforms (such as TikTok).

3.3 The Moderating Effect of Cultural Differences

The cultural sensitivity of the interactive path of symbols further intensifies the effect difference between the two types of consumption:

3.3.1 Collectivist culture (e.g., China, Japan)

Symbolic consumption is more likely to trigger "face competition", and symbolic display should conform to group norms (such as "low-key luxury"); sharing of experiential consumption should avoid "ego-centered" narrative, and emphasize collective values (such as "family travel" is more acceptable than "personal adventure").

3.3.2 Individualistic culture (such as the United States and Germany):

Symbolic consumption, characterized by individual expression (such as tattoos and niche brands), is more encouraged; the narrative of "unique experiences" in experiential consumption (like extreme sports) tends to receive positive feedback[14]. Symbolic consumption relies on the visibility and institutionalized meaning of material symbols, which holds an advantage in non-sharing scenarios but is constrained by cultural norms and the purity of motives. Experiential consumption achieves symbolic transmission through narrative sharing and emotional resonance, showing significant effects in high-sharing scenarios, yet it depends on individuals' social skills and platform characteristics.

4 THEORETICAL DEBATE AND INTEGRATION

4.1 Key Points of Contention

There are three core controversies in the existing research on the influence mechanism of symbolic consumption and experiential consumption on happiness, which essentially reflects the complexity and context-dependence of consumer behavior from the perspective of symbolic interactionism:

Controversy 1: The persistence of symbols —— the difference between "time discounting" of substances and experiences

Supporters argue that symbolic consumption (such as luxury goods and collectibles) continuously conveys identity value through the enduring presence of material symbols (like wearing branded watches or displaying artworks), with its happiness effect decaying more slowly over time [15]. For example, a tracking study found that consumers' self-esteem after purchasing luxury goods remained stable for six months [16]. The visibility and social consensus of material symbols (such as the institutionalization of brand status) make their significance less likely to fade over time. Critics point out that the happiness derived from experiential consumption (such as travel and concerts) relies on the narrative reconstruction of emotional memories. Although memories may be "rosy-filtered" (rosy retrospection) over time, their effects are influenced by sharing frequency —— if there is a lack of subsequent social interaction, the rate of happiness decay may be faster than that of symbolic consumption[7]. Which is more enduring: the "material solidification" of symbols or the "narrative fluidity" of memories?

Controversy 2: Cultural differences —— The "show-off stigma" trap in collectivism

In collectivist cultures such as East Asia and Latin America, symbolic consumption is often stigmatized as "showboating," challenging the norms of group harmony[14]. For instance, Chinese consumers must carefully balance the desire for status enhancement with the risk of jealousy when purchasing luxury cars[16]. In collectivist cultures, the happiness effect of symbolic consumption may be offset by social risks, while experiential consumption (such as family trips) is more readily accepted due to its alignment with the narrative of "collective interest." In individualist cultures like those in Europe and America, symbolic consumption is seen as a right to express personal identity, and society has a higher tolerance for "showboating"[12]. For example, buying a niche designer brand in the United States is viewed as an extension of one's unique self rather than a tool for comparison. Does the cultural construction of symbolic meaning determine the priority of happiness derived from different types of consumption?

Controversy 3: The moderating effect of individual traits —— self-construction

Independent individuals (such as North American consumers) highlight their uniqueness through differentiated symbols (such as limited editions and niche brands), with their happiness often stemming from symbolic consumption as an identity statement. Experiments show that after purchasing symbolic products, the clarity of self-concept significantly increases for such consumers[17]. Dependent individuals (such as East Asian consumers) tend to strengthen relational bonds through experiential consumption (such as family gatherings and group travel), with their happiness relying on social recognition rather than personal expression. Research indicates that after sharing experiential experiences, dependent consumers experience twice the increase in a sense of belonging compared to independent individuals [9]. Does self-construction type serve as a prerequisite for consumption choices?

4.2 Integration Framework: Three-Dimensional Model of "Consumption Type-Symbolic Interaction-Happiness"

In order to solve the above disputes, this paper puts forward an integrative theoretical framework (see Table 1), which emphasizes that the impact of consumption type on happiness needs to be realized through the process of symbolic interaction, and is subject to the triple regulation of scene, culture and individual characteristics:

Table 1 Integrated Model of Consumption Type, Symbolic Interaction and Happiness

Core dimensions of the model	
Consumer type dimension	
Symbolic consumption	dependence on the visibility and institutionalized meaning of material symbols;
Experience consumption	convey symbolic value through narrative sharing and emotional resonance.
The interactive process of symbols	
Identity display	visibility of symbols (such as luxury Logo) or narrative (such as travel story);
Social feedback	the interpretation of symbols by others (such as respect, jealousy) and interactive behaviors (such as likes, avoidance).
Happiness output	
Subjective well-being	self-worth, positive emotions;
Social well-being	a sense of belonging, social identity.

Mechanism of adjustment variable	
Scene adjustment	
No sharing scenario	the symbolic visibility of consumption leads tohappiness (such as the display of famous watches in the workplace);
High sharing scenarios	Experiences that are more narrative are more likely to receive positive feedback (such as social media travel logs).

Cultural regulation	
Collectivism culture	the social risk of symbolic consumption increases, and the collective narrative advantage of experiential consumption is highlighted
Individualistic culture	the expression of individuality in symbolic consumption is more free, and the unique narrative of experience consumption is more highly valued.
Individual trait regulation	
Independent self-construction	symbolic consumption enhances the clarity of self-concept through differentiated symbols
Interdependent self-construction	experiential consumption enhances social belonging through relational connection.

5 CONCLUSION AND DISCUSSION

5.1 Explore the New Form of Symbol Interaction in the Online and Offline Integration Scenario

With the penetration of digital technology, the integration of virtual and real consumption scenarios is reconstructing the path of symbolic interaction. Future research needs to focus on the following issues:
Visibility and identity construction of virtual symbols
Social Media Check-in Mechanism: When users share their consumption experiences on online platforms (such as Instagram, Xiaohongshu), they convey identity through visual symbols (like filters, tags) and narrative labels (such as "MinimalistLife" "LuxuryTravel"). How can this behavior integrate the "material symbols" of symbolic consumption with the "narrative symbols" of experiential consumption to form a composite identity display?
How do the consumption behaviors of virtual goods in the metaverse (such as NFTs, such as virtual clothing and digital art) and the metaverse space (such as Decentraland) redefine "identity declaration" through cross-scene symbol liquidity (such as wearing a virtual image Gucci NFT to enter offline activities)? Does such a symbol weaken the necessity of material carriers?

5.2 Deepen the Classification Study of Symbolic Consumption

Symbolic consumption is not a single category, and the internal differences of its impact on happiness need to be refined:
The Contrast Between Luxury Goods and Subcultural Symbols: Relying on brand history and class consensus (such as Hermes' "elite symbol"), their happiness effects are more stable but vulnerable to materialism criticism. For subcultural groups like trendy brands and figurines, their symbolic meanings stem from internal group codes (such as the term "otaku"), which may enhance group happiness by resisting mainstream culture. It needs to be verified: Do niche symbols better meet the "rebellious identity" needs of Generation Z?
The Moral Symbolization of Sustainable Consumption: Purchasing eco-friendly products (such as organic food and recycled material clothing) is seen as a symbol of "moral identity." However, the symbolic transmission faces dual challenges: Greenwashing Risk: False advertising by companies can distort the symbolic meaning, eroding consumer trust (e.g., "greenwashing"); Moral Superiority Trap: Sustainable consumption may be interpreted as "moral preaching," causing others to feel repulsed (e.g., "the arrogance of vegetarians") [18].
Symbolic Upgrade of Functional Products: Traditional functional products (such as home appliances and stationery) are endowed with "lifestyle symbols" through design upgrades (like Muji's minimalist aesthetics). The research needs to address: How do these "de-branding" symbols balance function and meaning? Does their happiness effect depend on specific cultural contexts (such as Japanese "wabi-sabi" aesthetics vs. Western pragmatism)?

5.3 Critical Reflection on the Measurement Paradigm of "Happiness"

Most existing studies rely on subjective well-being scales (such as SWLS), but their limitations call for a multidimensional measurement framework:

5.3.1 The tension between short-term sentiment and long-term well-being

Immediate bias of subjective evaluation: Questionnaire survey is easily disturbed by recent emotions (such as the short-term pleasure after buying luxury goods), and ignores long-term psychological well-being (such as self-realization). Longitudinal tracking research should be introduced to compare the decline curve of happiness after consumption[7].
Cultural differences blind spot: Western scales (such as PANAS) emphasize individual emotions, while happiness in East Asian culture may depend more on social harmony (such as "satisfaction with others"). Cultural adaptation indicators (such as "face satisfaction scale") need to be developed.

5.3.2 The paradigm shift from "happiness" to "meaning"

The Inspiration from Positive Psychology: Drawing on the PERMA model [19], well-being is broken down into five dimensions—positive emotions (P), engagement (E), relationships (R), meaning (M), and achievement (A)—to evaluate the differential contributions of consumption behavior to each dimension. For example, symbolic consumption may be more associated with "achievement," experiential consumption with "relationships," and

sustainable consumption may enhance long-term well-being through the "meaning" dimension.

5.3.3 The involvement of physiology and neuroscience

Biomarker measurement: cortisol levels and heart rate variability (HRV) were used to quantify the stress-relieving effect of consumption behavior; Exploration of neural mechanisms: Using fMRI to compare the differences in brain activation between symbolic consumption (e.g., seeing luxury Logo) and experiential consumption (e.g., recalling travel) (e.g., reward system vs. default mode network).

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EXPLORING THE IMPACT OF THE COLLABORATIVE KOL-KOC DUAL-PATH MECHANISM ON BEAUTY CONSUMPTION DECISIONS AMONG GENERATION Z WOMEN ON REDNOTE: USING DUAL AISAS MODEL

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Abstract: In the context of the rapid growth of digital marketing, the "grass-planting" marketing model on social e-commerce platforms has a significant influence on consumer purchasing behavior. Rednote, as a popular social e-commerce platform combining social networking, shopping, and content sharing, has become a major hub for "grass-planting" marketing, especially in the beauty industry, due to its rich content ecosystem and vast young user base. KOLs (Key Opinion Leaders) and KOCs (Key Opinion Consumers) are central to the "grass-planting" mechanism. This study investigates whether and how KOLs and KOCs influence consumer purchasing decisions through the publication of beauty-related "grass-planting" notes, and explores the relationship between these two types of influencers. Focusing on beauty-related "grass-planting" notes on Rednote and Generation Z women as the core consumer group, the study conducts empirical research based on the Double AISAS model. The findings reveal that KOLs drive the traditional AISAS path through professional content creation, enhancing brand exposure and increasing purchase conversion rates. In contrast, KOCs activate the A+ISAS path by sharing authentic experiences, promoting secondary dissemination, and converting private domain traffic. Both mechanisms work synergistically, driving the full conversion process from awareness to purchase. This study enriches consumer decision-making theory and provides theoretical and practical guidance for developing targeted marketing strategies for beauty brands, as well as for optimizing Rednote's platform algorithms and functionalities.
Keywords: Rednote; Beauty "grass-planting" notes; Generation Z women; Dual AISAS model; KOL and KOC; Synergistic effect

1 INTRODUCTION

In the current environment where internet e-commerce and mobile short videos are thriving, online shopping is no longer confined to traditional e-commerce platforms. People are gradually turning to social e-commerce platforms, with Rednote being one of the typical representatives. Its unique "grass-planting" marketing model has played a crucial role. According to data from the Weibo Easy Trading Platform, the consumption scale of Rednote has continuously increased in recent years, with the number of orders in 2023 increasing by 59.7% year-on-year, and the transaction amount growing by 49%. Rednote has become the social e-commerce platform with the highest brand recognition. Generation Z female consumers, as the core group of Rednote, have significant purchasing power that cannot be underestimated.

Previous research has explored the marketing effects of social media from multiple perspectives. Zhang Jian, based on the AITS model, examined the different impacts of interactive, narrative, and "grass-planting" content marketing on consumer decision-making, with "grass-planting" content marketing being the most effective in promoting consumer transactions and sharing. Chen Ming and Yin Jialu revealed the balancing mechanism between commercialization and content value among knowledge influencers[1]. Yan Yuelong discussed the essential differences in the communication logic between KOLs and KOCs[2]. It is worth noting that existing studies mainly focus on the mechanisms of single influencer types and lack a systematic exploration of the relationship between KOLs and KOCs, leaving a theoretical gap.

The purpose of this study is to construct a framework to understand the impact of beauty "grass-planting" notes on Rednote on the purchasing decisions of Generation Z female users and to validate this framework with empirical data. Based on this, the study raises two key questions: first, do KOLs and KOCs' beauty "grass-planting" notes influence consumer purchasing decisions, and if so, how? Second, if the beauty "grass-planting" notes of KOLs and KOCs influence consumers' purchasing decisions, is there a connection between them? What kind of relationship exists? A deeper exploration of these issues not only contributes to enriching consumer decision-making theory but also provides valuable insights for developing targeted marketing strategies for beauty brands, as well as optimizing Rednote platform algorithms and functionalities. This holds significant theoretical and practical significance.

2 LITERATURE AND THEORY

2.1 Basic Concepts

2.1.1 Rednote APP

Rednote is a lifestyle sharing and social e-commerce platform founded in 2013. Initially, it focused on sharing overseas shopping experiences but gradually expanded into various vertical fields such as beauty, fashion, travel, and food. By 2023, the platform had over 300 million registered users, with 74.1% of them being post-90s and post-00s, and Generation Z women as the core group. Users share their product experiences and consumption decisions through text, images, and short videos. Since 2014, Rednote has gradually developed a "grass-planting" feature, which encourages users to generate content (UGC) or rely on Key Opinion Leaders (KOLs) to promote products and stimulate purchase desire, forming a closed-loop of "social + consumption."

Research on Rednote mainly focuses on marketing strategies, user behavior, and platform mechanisms. Chen Ming and Yin Jialu focus on the marketing strategies of knowledge influencers under the "grass-planting" economy, pointing out that knowledge influencers monetize traffic through professional content and emotional connections[1], with their core value lying in balancing knowledge dissemination and commercialization needs. Jian Yu analyzed Rednote's KOL marketing strategies and explored the impact of social media marketing on consumer purchase intentions[3], which is important for understanding the practical effects of Rednote's KOL marketing strategies. Fan Qunlin studied the marketing strategy innovation of Rednote's social e-commerce platform[4], emphasizing the importance of innovating platform functions, building strong connections with users, improving market response speed, and establishing long-term relationships, which provide insights for the development of innovative marketing strategies on Rednote.

2.1.2 "Glass-Planting"

"Grass-planting" is an emerging consumer cultural phenomenon that refers to the act of stimulating others' purchase intentions through genuine product experiences or recommendations shared on social media. Its model includes user-generated sharing, KOL professional reviews, and brand collaborations, with the subsequent act of "pulling out the grass(de-influencing)." In addition to Rednote, platforms such as Douyin, Kuaishou, Weibo, and Bilibili also integrate "grass-planting" functions through short videos and live streaming, forming a multi-platform competitive landscape, especially in the beauty sector.

Li Zhongmei and Huang Min argue that Rednote has built a "grass-planting" marketing model that combines content ecosystem, word-of-mouth[5], brand, innovative UGC, and self-operated e-commerce strategies, highlighting the importance of content marketing for brand development. They provide a strategy framework for effective "grass-planting" marketing on Rednote. Dong Yuanyuan analyzed the differentiated effects of three types of "grass-planting" formats (text, image, video, and live-streaming) on consumer flow experiences based on the SOR model[6]. The study found that live-streaming grass-planting is the most effective, while video "grass-planting" has the most significant mediating effect. Qian Jingjing and Zhao Jingjing verified that "grass-planting" short video marketing, with its usefulness, ease of use[7], life-like characteristics, and interactivity, can promote emotional arousal, positively influencing consumer purchase intentions. This provides a new perspective for research in the short-video marketing field.

2.1.3 KOL and KOC

KOL (Key Opinion Leader) refers to someone with expertise, rich experience, and significant influence in a particular field, and who has a large following. Their core characteristic is the ability to produce content in a vertical field and provide professional brand endorsement. In social and marketing contexts, KOLs have a significant influence on the attitudes and behaviors of their followers. KOC (Key Opinion Consumer), on the other hand, emphasizes participants in consumer behavior who are closer to ordinary consumers. KOCs, as active sharers among regular users, gain influence from real experiences and emotional resonance within their social relationship networks.

Yan Yuelong pointed out the essential differences in the communication logic between KOLs and KOCs. The former relies on professionalism and public domain traffic[2], while the latter empowers private domain traffic with authenticity, emphasizing the high conversion rate achieved by KOCs through emotional bonds, reflecting the "KOL downward, KOC upward" marketing trend. Li Li empirically analyzed the trust-driven differences between KOLs and KOCs in the influencer economy based on consumer trust dimensions[8]. It was found that ability and charm-driven trust dominate KOLs, while good-will and honesty-driven trust drive KOCs, and a five-dimensional scale including institutional trust was developed.

2.2 Research Model and Hypotheses Development

With the evolution and development of media, consumer purchasing behavior patterns have also changed. Advertising companies have used various models related to the consumer decision-making process to analyze consumers' purchasing behaviors and purchase intentions. In 1898, American advertising scholar E.S. Lewis proposed the AIDMA model, which suggests that consumers go through five stages from exposure to information to the final purchase: Attention, Interest, Desire, Memory, and Action. Later, to meet the demands of the digital age, the Japanese advertising company Dentsu upgraded the AIDMA model and proposed another consumer behavior model, AISAS, in 2008. This model better explains consumer behavior activities on the internet and includes five stages: Attention, Interest, Search, Action, and Share.

Today, people are more inclined to word-of-mouth communication than traditional advertising. According to relevant data, compared to notes from celebrities or KOLs, "grass-planting" notes posted or shared by KOCs, ordinary users, or friends are more effective in driving purchase behavior, as they include consumer emotions and more easily trigger consumers' desire to purchase or share. The traditional AISAS model focuses on the linear decision-making path of consumers in the digital age, but the interactivity and networked features of social media have made consumer

decision-making behaviors non-linear, especially as sharing behavior may trigger a new round of dissemination effects. In response, Dentsu and digital marketing company Atara LLC collaborated in 2015 to propose a new AISAS model, called the "Dual AISAS Model", to enhance digital communication and maximize sales [9]. The Dual AISAS model builds upon the traditional path and introduces a new "desire to share" (A+AISAS) process. It emphasizes the activation effect of users' sharing behavior on social networks: shared content spreads through social relationship chains, attracting others' Attention, Interest, and secondary dissemination (Spread), forming a cycle of diffusion. The core innovation of the Dual AISAS model lies in its dual-path integration mechanism. The first path (traditional AISAS) focuses on the individual decision-making process from attention to purchase, with core variables being the driving factors of purchase desire, such as content attractiveness and information credibility. The second path (A+ISAS) emphasizes the activation effect of users' sharing behavior on social networks, with core variables being the triggering mechanisms for sharing desire, such as social identity and emotional resonance. The Dual AISAS model is highly applicable to the study of social platforms like Rednote, which are centered around user-generated content (UGC). Beauty-related content, with its strong visual and interactive characteristics, can achieve viral dissemination through the dual paths. Generation Z women, as the core audience for Rednote's beauty content, exhibit characteristics such as segmentation, emotional engagement, and social dependency, which align well with the dual-path logic of the Dual AISAS model.

In the Web 2.0 era, scholars suggest that brands cooperate with KOLs, as they are more likely to help brands capture the public's attention. The attention stage highlights that influence starts from the outside in, so the extent of influence depends on the number of KOLs or celebrities the users follow. The vertical flow in Figure 1 shows that users' attention is captured by the notes posted by KOLs and celebrities. The rate of user attention and trust determines the intensity of user interest. The higher the attention and trust towards influencers, the greater the interest generated [10]. When a user posts a beauty-related "grass-planting" note, they receive feedback in the form of "likes", "comments", "shares", and "follows". The more followers, the more intense the feedback, which can stimulate more attention from others. Rednote, as a digital social media platform, quickly boosts initial exposure through KOL content with professional endorsement. Fans, based on trust in the KOL's expertise,tend to develop a strong interest in the beauty products recommended by them, even making direct purchases. Based on the above research, the following hypotheses are proposed:

H1: KOL's beauty "grass-planting" notes have a positive impact on user attention.
H2: KOL's beauty "grass-planting" notes have a positive impact on user interest.
H3: KOL's beauty "grass-planting" notes have a positive impact on user search intent.
H4: KOL's beauty "grass-planting" notes have a positive impact on user purchase or action intent.
H5: KOL's beauty "grass-planting" notes have a positive impact on user sharing intent.

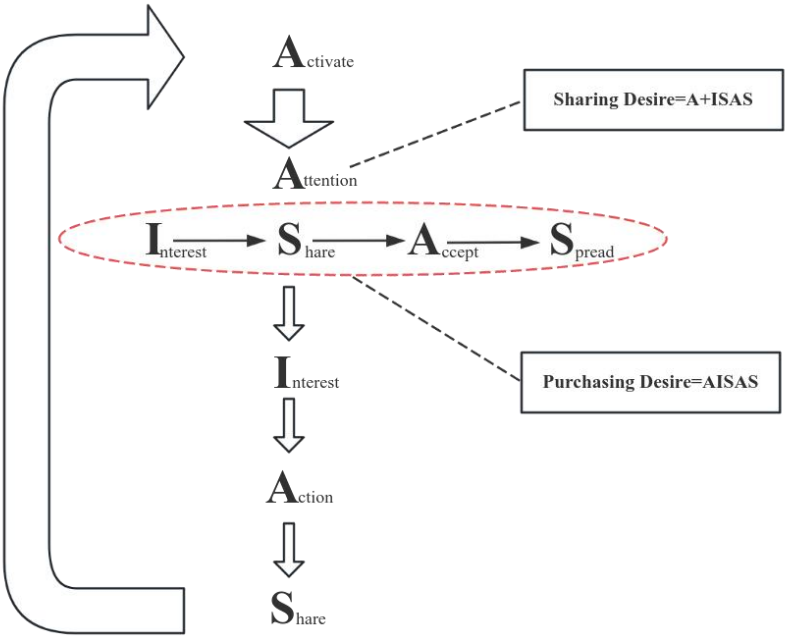

Figure 1 The Dual AISAS Model

In the A+ISAS path, sharing behavior is not only the end point of the purchase decision but also the starting point for a new round of dissemination. Figure 1 shows the inward influence's beginning. Cheah et al. found that when information is spread by close friends[11], it is more widely accepted than when spread by celebrities, and the former is more effective than the latter. KOCs, as active sharers among ordinary users, gain influence from real experiences and emotional resonance within their social relationship chains. KOCs are characterized by authenticity and trust, and they can achieve high conversion from exposure (public domain traffic) to conversion (private domain traffic) [2].

According to the multi-step flow theory, once information is transmitted to followers by opinion leaders (e.g., KOLs), followers further diffuse the content through private networks (e.g., friends, followers) and extended networks (e.g., cross-platform links). This diffusion process relies on "emotional resonance" and "social identity" in social interactions. Shintara and Yun used the "Dual AISAS model" to explore consumer behavior on SNSs[12], finding that consumers tend to trust information conveyed by other consumers, and they are more inclined to share and recommend products through SNSs than before. This activity can attract others' attention and influence other users' purchasing behaviors. Based on the above research, the following hypotheses are proposed:

H6: KOC's sharing has a positive impact on user activity.
H7: KOC's sharing has a positive impact on user attention.
H8: KOC's sharing has a positive impact on user interest.
H9: KOC's sharing has a positive impact on user sharing intent.
H10: KOC's sharing has a positive impact on user information acceptance.
H11: KOC's sharing has a positive impact on user dissemination intent.

3 METHODOLOGY

3.1 Questionnaire Collection

The questionnaire for this study was conducted using a random sampling method. The survey was designed and distributed via Wenjuanxing and collected on online platforms such as WeChat and Rednote. Screening questions were included to exclude invalid responses. A total of 459 questionnaires were distributed, and 444 valid responses were collected. SPSSAU was used as the primary analysis tool for testing the hypotheses proposed in this study.

3.2 Sample Description

Descriptive statistical analysis was conducted on the data from the questionnaire to reflect the overall representativeness of the sampled population. Table 1 lists the demographic characteristics of the sample.

Table 1 Descriptive Statistics of the Sample(N=459)

question	options	Frequency (N=459)	Percentage (%)
Your gender:	female	450	98.04
	male	9	1.96
Have you ever browsed beauty "glass-planting" notes on Rednote: (n=450)	yes	444	98.67
	no	6	1.33
Your age group is: (N=444)	1995-1999	81	18.24
	2000-2004	261	58.78
	2005-2009	102	22.97
Your occupation is: (N=444)	students	285	64.19
	employee	114	25.68
	freelancer	33	7.43
	others	12	2.70
Your disposable monthly beauty spending: (N=444)	Less than 500 yuan	210	47.30
	500-1000 yuan	162	36.49
	1001-2000 yuan	54	12.16
	More than 2,000 yuan	18	4.05
How often do you use Rednote:(N=444)	Multiple times per day	231	52.03
	once a day	75	16.89
	3-5 times per week	84	18.92

question	options	Frequency (N=459)	Percentage (%)
The average length of time you spend browsing Rednote's beauty content per day is: (N=444)	occasional use	54	12.16
	Less than 15 minutes	135	30.41
	15-30 minutes	162	36.49
	30 minutes - 1 hour	108	24.32
	More than 1 hour	39	8.78
Which of the following is a higher percentage of the beauty influencers you follow:(N=444)	KOL (Professional beauty influencers with >50,000 followers. (e.g., Li Jiaqi, etc.)	141	31.76
	KOC/Ordinary user (Ordinary users with < 50,000 followers. e.g., college student non-pro influencers, etc.)	168	37.84
	both are equal	135	30.41

According to the statistical results, more than half of the respondents were born between 2000 and 2004, accounting for 58.78%, and the majority of respondents were students, representing 64.19%. In terms of monthly average spending on beauty products, most respondents reported spending less than 500 yuan (47.3%) or between 500–1000 yuan (36.49%), indicating that most Generation Z female consumers are relatively cautious in their beauty consumption. In terms of Rednote usage frequency, the highest proportion (52.03%) of users reported using the platform multiple times a day. Regarding the average daily time spent browsing Rednote, the highest proportion (36.49%) of users spent 15–30 minutes, followed by 30.41% who spent less than 15 minutes. This suggests that most users spend relatively little time on Rednote, possibly due to the frequent content updates, causing users to habitually browse quickly. Among the types of beauty influencers followed, KOCs or ordinary users made up the highest proportion at 37.84%, indicating that beauty content shared by ordinary users is gaining increasing popularity.

3.3 Variable Measurement

The variables involved in this study include Attention (Att), Interest (Int), Search (Stch), Action (Act), Share (Sha), Activate (Actv), Attention (Attnt), Interest (Inter), Share (Shre), Accept (Accpt), and Spread (Sprd). This study referenced established scales from previous scholars and designed the items based on literature review and online research. The final scale design is shown in Table 2:

Table 2 Variable Measurement Scale

Variables	Items	Statement	Scale source
Attention (Att)	Att1	The beauty "grass-planting" notes posted by KOLs catch my attention.	Wei&Lu [13] Cheah, J.-H., Ting, H., Huei Cham, T., & Ali Memon, M. [11].
	Att2	The beauty "grass-planting" notes posted by KOLs fully capture my attention.	
	Att3	The beauty "grass-planting" notes posted by KOLs catch my eye.	

Interest (Int)	Int1	After reading the beauty "grass-planting" notes posted by KOLs, I am very interested in the notes.	Wei&Lu [13] Cheah, J.-H., Ting, H., Huei Cham, T., & Ali Memon, M. [11].
	Int2	After reading the beauty "grass-planting" notes posted by KOLs, I am interested in the related beauty products.	
	Int3	The beauty "grass-planting" notes posted by KOLs leave a good impression on me regarding the related beauty products.	
Search (Stch)	Stch1	After reading the beauty "grass-planting" notes posted by KOLs, I will search for information about the beauty products.	Wei&Lu [13] Cheah, J.-H., Ting, H., Huei Cham, T., & Ali Memon, M. [11]. Meng Fei
	Stch2	After reading the beauty "grass-planting" notes posted by KOLs, I will search for online reviews of the beauty products.	
	Stch3	After reading the beauty "grass-planting" notes posted by KOLs, I will compare the prices of the beauty brand products.	
Action (Act)	Act1	After reading the beauty "grass-planting" notes posted by KOLs, I believe that the beauty brand's products are worth trying.	Wei&Lu [13] Cheah, J.-H., Ting, H., Huei Cham, T., & Ali Memon, M. [11]. Meng Fei
	Act2	After reading the beauty "grass-planting" notes posted by KOLs, I will develop a desire to purchase the beauty products.	
	Act3	If I already have a purchase need, I will prioritize purchasing the brand/product recommended by the KOL.	
Share (Sha)	Sha1	After reading the beauty "grass-planting" notes posted by KOLs, I will forward the notes to my friends.	Wei&Lu [13] Cheah, J.-H., Ting, H., Huei Cham, T., & Ali Memon, M. [11].
	Sha2	After reading the beauty "grass-planting" notes posted by KOLs, I will share information about the related beauty products with my friends.	
	Sha3	After purchasing and using the beauty products, I will share my experience and comment on the products.	
Activate (Actv)	Actv1	The beauty notes shared by KOCs have sparked my interest.	Awasthi, A. K., & Choraria, S. [14]. Sara Javed, Md. Salamum Rashidin & Yun Xiao [15]
	Actv2	I will follow and check the notes shared or reposted by KOCs in beauty communities.	
	Actv3	I will click to view the details of beauty products due to KOC's real feedback (such as reviews from ordinary users).	
Attention (Attnt)	Attnt1	The beauty "grass-planting" notes shared by KOCs caught my attention.	Awasthi, A. K., & Choraria, S. [14]. Sara Javed, Md. Salamum Rashidin & Yun Xiao [15]

	Attnt2	The beauty "grass-planting" notes shared by KOCs aroused my interest.	
	Attnt3	The beauty "grass-planting" notes shared by KOCs caught my eye.	
Variables	Items	Statement	Scale source
Interest (Inter)	Inter1	I like the beauty "grass-planting" notes shared by KOCs.	Awasthi, A. K., & Choraria, S. [14]. Sara Javed, Md. Salamum Rashidin & Yun Xiao [15]
	Inter2	The beauty "grass-planting" notes shared by KOCs leave a good impression on me.	
	Inter3	KOC's recommendations make me more confident in the cost-effectiveness of beauty products.	
Share (Shre)	Shre1	I am willing to forward the beauty "grass-planting" notes shared by KOCs because their content is more credible.	Awasthi, A. K., & Choraria, S. [14]. Sara Javed, Md. Salamum Rashidin & Yun Xiao [15] The definition of this study
	Shre2	I will interact in the comments section of KOC's beauty "grass-planting" notes (e.g., asking about their experience).	
	Shre3	After reading the beauty "grass-planting" notes shared by KOCs, I am more willing to share my own experience with beauty products.	
Accept (Accpt)	Accpt1	The beauty "grass-planting" notes shared by KOCs affect my acceptance of product information.	Awasthi, A. K., & Choraria, S. [14]. Sara Javed, Md. Salamum Rashidin & Yun Xiao [15] The definition of this study
	Accpt2	I will refer to the comments in KOC's beauty "grass-planting" notes to decide whether to purchase the product.	
	Accpt3	I tend to purchase the beauty products recommended by KOCs (compared to those recommended by influencers or celebrities).	
Spread (Sprd)	Sprd1	Through KOC's notes, I learn about more niche beauty brands and recommend them to others.	Awasthi, A. K., & Choraria, S. [14]. Sara Javed, Md. Salamum Rashidin & Yun Xiao [15] The definition of this study
	Sprd2	I will forward and share KOC's beauty "grass-planting" notes to my social circle, along with my comments.	
	Sprd3	The KOC notes I share are often re-shared or liked by other users.	

3.4 Reliability and Validity Analysis

3.4.1 Relisbility analysis

Reliability analysis was performed on the statistical results of the survey using the Cronbach's α coefficient, a commonly used method in questionnaire surveys. The Cronbach's α coefficient measures the reliability of a scale by calculating the average correlation coefficient (r). A Cronbach's α coefficient greater than 0.8 indicates high reliability; a coefficient between 0.7 and 0.8 indicates good reliability; a coefficient between 0.6 and 0.7 indicates acceptable reliability; and a coefficient below 0.6 indicates poor reliability.

Table 3 Reliability Analysis of Questionnaire Scales

Variable	Number of items	Cronbach's Alpah
Overall Scale	33	0.831
Attention (Att)	3	0.835
Interest (Int)	3	0.730
Search (Srch)	3	0.721
Action(Act)	3	0.760
Share (Sha)	3	0.835
Activate (Actv)	3	0.757
Attention (Attnt)	3	0.869
Interest (Inter)	3	0.789
Share (Shre)	3	0.673
Accept (Accpt)	3	0.788
Spread (Sprd)	3	0.808

As shown in Table 3, the overall Cronbach's α coefficient for the scale is 0.831, with the lowest Cronbach's α coefficient for any variable being greater than 0.6, indicating good reliability. The results show that the scale design is reasonable and exhibits good internal stability and consistency, making it suitable for further analysis.

3.4.2 Validity analysis

The validity of the scale was tested using the KMO and Bartlett's test. When the KMO value exceeds 0.8, it indicates that the scale is highly suitable for data extraction. A KMO value between 0.7 and 0.8 indicates that the scale is reasonably suitable for data extraction. A KMO value between 0.6 and 0.7 indicates that data extraction can proceed. A KMO value below 0.6 suggests that information extraction is difficult. The KMO value for this study is 0.825, which is above 0.8, and the p value is 0.000, less than 0.01, indicating that factor analysis can be conducted. See Table 4.

Table 4 KMO and Bartlett's Test

KMO value		0.825
Bartlett's Test of Sphericity	Approximate Chi-square (math.)	1376.065
	df	55
	p value	0.000

4 RESEARCH RESULTS

4.1 Correlation Analysis

Correlation analysis is a statistical method used to examine the relationship between two or more variables, which can help understand the associative properties between them. In this study, Pearson Correlation Coefficient method was used to test the relationships between 11 variables. The results of the correlation test are shown in Table 5.

Table 5 Pearson Correlation Coefficients

	Mean	Standard Deviation	Attention (Att)	Interest (Int)	Search (Stch)	Action (Act)	Share (Sha)	Activate (Actv)	Attention (Attnt)	Interest (Inter)	Share (Shre)	Accept (Accpt)	Spread (Sprd)
Attention (Att)	3.905	0.770	1										
Interest (Int)	4.101	0.633	0.453**	1									
Search (Srch)	4.095	0.633	0.445**	0.413**	1								
Action (Act)	3.910	0.797	0.359**	0.426**	0.499**	1							
Share (Sha)	3.818	0.889	0.285**	0.383**	0.308**	0.280**	1						
Activate (Actv)	4.027	0.779	0.493**	0.318**	0.208*	0.269**	0.376**	1					
Attention (Attnt)	3.951	0.853	0.334**	0.237**	0.355**	0.392**	0.179**	0.386**	1				
Interest (Inter)	4.072	0.746	0.355**	0.263**	0.268**	0.258**	0.220**	0.401**	0.326**	1			
Share (Shre)	4.054	0.652	0.268**	0.315**	0.177**	0.111*	0.302**	0.242**	0.261**	0.240**	1		
Accept (Accpt)	4.110	0.763	0.124**	0.372**	0.190**	0.229**	0.327**	0.270**	0.322**	0.319**	0.356**	1	
Spread (Sprd)	3.849	0.893	0.305**	0.337**	0.290**	0.244**	0.425**	0.285**	0.255**	0.465**	0.401**	0.339**	1

* $p<0.05$ ** $p<0.01$

From Table 5, it can be seen that Attention (Att) has significant positive correlations with Interest (Int), Search (Stch), Action (Act), Share (Sha), Activation (Actv), Attention (Attnt), Interest (Inter), Share (Shre), Acceptance (Accpt), and Spread (Sprd), with correlation coefficients all greater than 0. This indicates positive correlations between the variables.

4.2 Hypothesis Testing

Path analysis was used in this study to test the research model. The study first checked for collinearity issues among the variables. In the Pearson Correlation Coefficients, when the absolute value of the correlation between any two variables exceeds 0.8, it suggests the potential existence of collinearity problems. If the correlation coefficient between two variables is 1, it indicates absolute collinearity. According to Table 5, there are no pairs of variables with an absolute correlation coefficient greater than 0.8 in this study. Additionally, the Variance Inflation Factor (VIF) scores indicate that if a variable's VIF exceeds 5, it suggests collinearity. From Table 6, it can be seen that no variables have a VIF greater than 10, meaning there are no collinearity issues among the variables in this study.

Table 6 Colinear Diagnosis

Variable	VIF value	Tolerance
Attention (Att)	1.798	0.556
Interest (Int)	1.675	0.597
Variable	VIF value	Tolerance

Search (Srch)	1.628	0.614
Action (Act)	1.577	0.634
Share (Sha)	1.497	0.668
Activate (Actv)	1.661	0.602
Attention (Attnt)	1.484	0.674
Interest (Inter)	1.520	0.658
Share (Shre)	1.367	0.731
Accept (Accpt)	1.463	0.684
Spread (Sprd)	1.630	0.614

The study used SPSS to conduct path analysis and model construction. The initial model had a low fit, so model modification was made using the MI (Modification Indices) based on the relationships between the variables, and new paths were added. The model fit was improved. The recommended model fit indices are: RMSEA less than 0.10, RMR less than 0.05, CFI greater than 0.9, NFI greater than 0.9, IFI greater than 0.9, GFI greater than 0.9, and AGFI greater than 0.9. The fit results of the model in this study are as follows: RMSEA = 0.084, RMR = 0.044, CFI = 0.928, NFI = 0.909, IFI = 0.930, GFI = 0.945, AGFI = 0.907. The results of the measurement model indicate good model fit, and the model shown in Figure 2 has strong explanatory power.

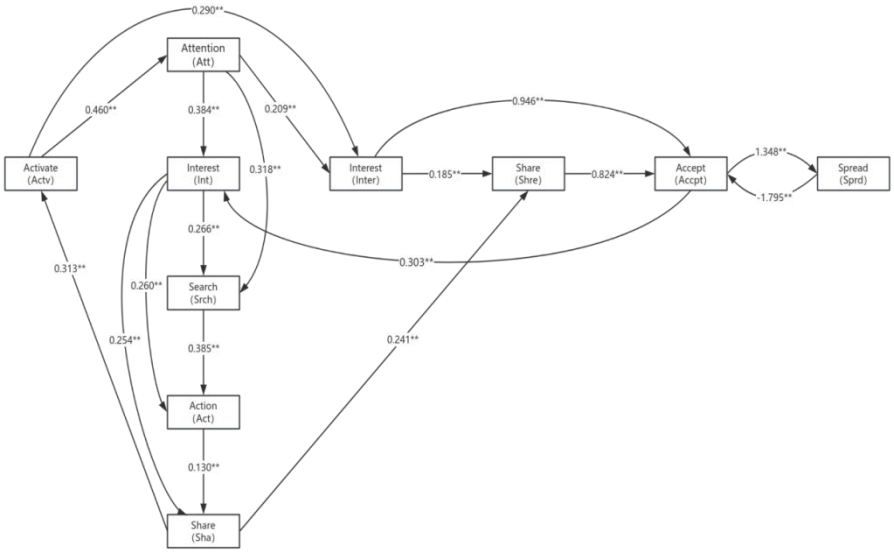

Figure 2 Diagram of the Dual AISAS Model

Table 7 shows the path coefficients after MI correction: Attention is significantly positively correlated with Interest (Int) and Search, Interest (Int) is significantly positively correlated with Search, Action, and Share (Sha), Search is significantly positively correlated with Action, Action is significantly positively correlated with Share (Sha), Share (Sha) is significantly positively correlated with Activate and Share (Shre), Activate is significantly positively correlated with Attention and Interest (Inter), Attention is significantly positively correlated with Interest (Inter), Interest (Inter) is significantly positively correlated with Share (Shre) and Accept, Share (Shre) is significantly positively correlated with Accept, Accept is significantly positively correlated with Spread and Interest (Int), and Spread is significantly negatively correlated with Accept. The results indicate that on Rednote, a platform centered around user sharing, the attention of Generation Z female consumers is attracted by the beauty "grass-planting" notes posted by KOLs, which have a significant impact on consumer interest (Int), promoting further search, purchase, and sharing of relevant beauty products and information on Rednote or other SNS platforms. Hypotheses H1, H2, H3, H4, and H5 are therefore supported. Additionally, consumer sharing on Rednote further activates their private network (e.g., friends, followers),

where KOC's beauty "grass-planting" notes play a major role, increasing followers' and friends' attention and interest in related beauty products and information, leading to purchase or further sharing. Consumers perceive KOC's beauty notes as more authentic and easier to accept and spread. Hypotheses H6, H7, H8, H9, H10, and H11 are therefore supported. Thus, the dual synergistic "grass-planting" mechanism of KOLs and KOCs plays an important role in enhancing the beauty consumption willingness of Generation Z women.

Table 7 Path Analysis Results

Hypotheses	Paths			p	Standardized path coefficient	Relationship
H1, H2	Attention (Att)	→	Interest (Int)	0.000	0.384	Supported
	Attention (Att)	→	Search (Stch)	0.000	0.318	
H3	Interest (Int)	→	Search (Stch)	0.000	0.266	Supported
	Interest (Int)	→	Action (Act)	0.000	0.260	
	Interest (Int)	→	Share (Sha)	0.000	0.254	
H4	Search (Stch)	→	Action (Act)	0.003	0.385	Supported
H5	Action (Act)	→	Share (Sha)	0.000	0.130	Supported
H6	Share (Sha)	→	Activate (Actv)	0.000	0.313	Supported
	Share (Sha)	→	Sharing (Shre)	0.000	0.241	
H7	Activate (Actv)	→	Attention (Att)	0.000	0.460	Supported
	Activate (Actv)	→	Interest (Inter)	0.000	0.290	
H8	Attention (Att)	→	Interest (Inter)	0.000	0.209	Supported
H9	Interest (Inter)	→	Share (Shre)	0.000	0.185	Supported
	Interest (Inter)	→	Accept (Accpt)	0.000	0.946	
H10	Share (Shre)	→	Accept (Accpt)	0.000	0.824	Supported
H11	Accept (Accpt)	→	Spread (Sprd)	0.000	1.348	Supported
	Accept (Accpt)	→	Interest (Int)	0.000	0.303	
	Spread (Sprd)	→	Accept (Accpt)	0.000	-1.795	

5 DISCUSSION

5.1 Research Findings

This study, based on the Dual AISAS model, systematically analyzes the synergistic effect and mechanisms of KOL and KOC beauty "grass-planting" notes on the purchase intentions of Generation Z female users on Rednote. The specific findings are as follows.

5.1.1 Differentiated mechanisms of KOL and KOC

KOL beauty "grass-planting" notes significantly drive the traditional AISAS path through professional content output. Their core value lies in enhancing users' initial attention and purchase conversion rates through the authority of the vertical field. With a large fan base and a professional image in a specific field, KOLs can rapidly increase brand exposure. KOL beauty "grass-planting" notes typically feature high visual quality and information density. Through

carefully designed titles, covers, and scene-based narratives, they attract the attention of Generation Z female users, quickly spark user interest with professional reviews and tutorial content, and naturally incorporate product selling points, significantly increasing user search and purchase conversion rates. KOL beauty "grass-planting" notes can rapidly build brand awareness in a short period and are often associated with clear commercial attributes, leading users to perceive KOLs as brand advocates representing the brand's stance.

KOC beauty "grass-planting" notes, on the other hand, activate the A+ISAS path through authentic experiences, using emotional resonance and trust within social relationship chains to drive secondary dissemination and conversion of private domain traffic. Although KOCs have fewer followers, the quality of the content they share is high, focusing on real experiences and stronger emotional resonance with more relatable characteristics. This weakens the commercial attributes, making users more likely to view the content from a consumer's perspective, thus creating "peer identification" and triggering the trust foundation for purchase decisions. For example, KOCs, through unfiltered lipstick swatches, everyday usage scenarios, or cost-effectiveness comparisons, can precisely address the pain points of their target users, stimulating active searches and sharing behaviors. While KOCs' beauty "grass-planting" notes are less influential than KOLs', their lower collaboration costs bring the advantage of matrix-based dissemination. When a large number of KOC/ordinary user beauty "grass-planting" notes are published on Rednote, the penetration ability of their information can rival that of KOLs. If the content quality is well-controlled, it can achieve cost-effective viral spread. KOCs' beauty "grass-planting" notes can also activate secondary dissemination (Interest → Spread) through the viral effects of social networks (e.g., WeChat Moments sharing, comment section interactions), generating long-tail traffic in the A+ISAS path.

5.1.2 Synergistic effect of KOL+KOC dual path

KOL beauty "grass-planting" notes have an advantage in the initial dissemination stage, making them suitable for quickly building brand recognition and achieving short-term exposure and conversion. KOC beauty "grass-planting" notes perform better in the sharing stage, as users are more likely to trigger social dissemination due to authentic experiences, leading to long-term trust and viral growth. The synergistic effect of the KOL + KOC dual path is mainly reflected in the fact that KOLs dominate the traditional path (AISAS) in the "awareness—decision" stage, while KOCs drive the diffusion path (A+ISAS) in the "sharing—activation" stage. Together, they form a closed-loop ecosystem of "professional guidance + real feedback", efficiently promoting the entire conversion process from awareness to purchase. This validates the effectiveness of the dual-path model.

5.2 Research Contributions

This study contributes to both the theoretical and practical understanding of consumer decision-making. From a theoretical perspective, this study builds on existing literature using the AISAS model to study consumer behavior and introduces the new "Dual AISAS Model", providing an in-depth exploration of how KOLs and KOCs impact the consumer decision-making process. By integrating the Double AISAS model with the non-linear and multi-interactive characteristics of social media, this study introduces the concept of "dual-path synergy", incorporating the non-linear interaction characteristics of social media into the consumer decision-making model, filling the gap left by traditional theories in addressing dynamic dissemination mechanisms. Additionally, based on the research of Yan Yuelong and Li Li [2,8], this study further clarifies the role boundaries of KOLs and KOCs: KOLs focus on public domain awareness building, while KOCs empower private domain conversion, providing a theoretical basis for tiered marketing strategies.

From a practical perspective, this study focuses on Rednote's beauty "grass-planting" notes and analyzes the effects of KOLs and KOCs on Generation Z female consumers' Attention (Att), Interest (Int), Search, Action, Share (Sha), Activate, Attention (Attnt), Interest (Inter), Share (Shre), Accept, and Spread. This enriches our understanding of each stage of the consumer decision-making process and provides new directions for future research. This study also offers practical insights for platform optimization and beauty brand marketing strategy enhancement. Rednote can strengthen the dual-path closed loop by weighting long-tail content through algorithms and implementing "one-click purchase" functions, while beauty brands can increase user retention by using a "KOL + KOC combined strategy".

5.3 Limitations

Like other empirical studies, this research has certain limitations. First, the study population is limited to Generation Z female consumers in mainland China, which may not represent other age groups, genders, or audiences from other countries and regions. Second, the research is confined to the Rednote platform and does not compare with other social e-commerce platforms, such as Tiktok and Kuaishou. Additionally, the study is limited to the beauty industry and may not be fully applicable to other industries or products. Finally, this study only uses cross-sectional data, rather than a longitudinal study, making it difficult to establish definitive causal relationships.

5.4 Future Research Directions

Given the limitations of this study, the following suggestions are made for future research. Future studies could investigate a broader range of audience types and other countries or regions, and test the model on other social e-commerce platforms to better understand the situation of digital influencers and consumer decision-making. Future research should also test the Dual AISAS model in other industries, such as food, tourism, and health, to enhance the robustness of the model. Additionally, follow-up surveys based on this study could further explore the causal

relationships between variables in the existing theoretical model and investigate the factors that influence the variables of the Dual AISAS model.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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A PREDICTIVE MODEL FOR STOCK PRICES BASED ON TRANSFORMER AND UTILIZING MULTIMODAL DATA

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Abstract: Stock market prediction necessitates effective multimodal data integration and robust uncertainty quantification. This paper proposes a novel Transformer-based architecture addressing two critical limitations of existing approaches: static cross-modal interaction and deterministic output assumptions. Our framework introduces (1) a multimodal subspace attention mechanism that projects numerical and textual features into orthogonal subspaces, enabling disentangled learning of modality-specific interactions through multiple attention heads, and (2) a dynamic gated recalibration module that adaptively adjusts modality contributions using time-variant weights. Evaluated on Technology Select Sector SPDR Fund (XLK) data with market sentiment feeds, the model achieves higher directional accuracy than conventional Transformers while reducing volatility period prediction errors. The integrated uncertainty quantification module further provides statistically reliable confidence intervals, verified through backtesting.
Keywords: Transformer networks; Multimodal fusion; Stock prediction; Uncertainty modeling; Dynamic attention subspaces

1 INTRODUCTION

Stock market prediction holds a pivotal position in financial research. Its accuracy directly impacts the success or failure of investment decisions and the effectiveness of risk management, and has long been the focus of attention in both academic and investment circles. Scholar Siladitya Chatterjee clearly pointed out in the paper "Comparative Study of Machine Learning Algorithms for Stock Market Prediction and Analysis of Correlation Between Nifty 50 and Global Indices" [1] that the trend of stock prices is the result of the intertwined action of multiple factors. Fluctuations in macro - economic indicators, changes in geopolitical situations, and the emotional ups and downs of market participants, etc., all have a significant impact on stock prices. Traditional single - modality prediction methods usually only conduct analysis based on historical trading data and are difficult to comprehensively and deeply grasp the internal connections among these complex factors. Moreover, the inherent uncertainty of the financial market further exacerbates the difficulty of prediction. As Liu, Q., Lin, S., & Zhu, Y. elaborated in "Stock Price Prediction Using Long Short - Term Memory and Transformer" [2], the high volatility and irregularity of stock prices make accurately predicting stock prices a highly challenging task. Therefore, integrating multi - modal data and effectively modeling the uncertainty in the prediction process have become the keys to improving the accuracy of stock market prediction.

Looking back on previous research related to stock prediction, the traditional ARIMA model can show certain advantages when dealing with data with linear characteristics. However, when faced with the widespread non - linear phenomena in the financial market, its prediction ability becomes inadequate. Scholars such as Indu Kumar clearly revealed the limitations of the ARIMA model in dealing with the non - linear characteristics of the financial market in "A Comparative Study of Supervised Machine Learning Algorithms for Stock Market Trend Prediction" [3]. In the field of deep learning, although the LSTM model has made some progress in time - series modeling and can capture some short - term dependencies, there are still obvious deficiencies in handling long - term dependency information. In recent years, the Transformer model has achieved breakthrough results in many fields such as natural language processing and computer vision with its unique multi - head self - attention mechanism. Scholars such as R. Sampada mentioned in "Stock Market Prediction Using Transformers" that although Transformer - based models (such as BERT and GPT - 2) have been attempted to be applied to stock market prediction [4], their potential in multi - modal data fusion has not been fully explored and exploited in the field of stock prediction. In view of this, this study attempts to give full play to the advantages of the Transformer model, combine it with multi - modal data fusion technology and uncertainty modeling methods, and then propose a more robust and efficient stock prediction method.

This paper puts forward two important innovation points in the research of stock prediction:

Multi - modal Data Fusion: This study innovatively adopts a dynamic fusion strategy to organically combine stock numerical data and market sentiment text data, aiming to significantly improve the model's ability to capture market dynamic changes. Currently, most multi - modal fusion methods merely use simple splicing or fixed - weight methods to combine text sentiment features with numerical data. This approach lacks effective consideration of the dynamic feature interaction of data, greatly limiting the fusion effect. This study will strive to break through this limitation. By constructing a dynamic interaction mechanism, the model can flexibly adjust the fusion weights and methods of different modal data according to real - time market changes, thus more accurately reflecting market dynamics.

Uncertainty Modeling: This study for the first time attempts to estimate both the mean and variance of the prediction results in the output of the Transformer model, so as to quantify the uncertainty of the prediction results and provide more powerful support for investors' risk management. In existing research, methods such as Bayesian neural networks

can model uncertainty, but they are often accompanied by high computational complexity, limiting their promotion in practical applications. The research on uncertainty modeling based on Transformer is still in its infancy, and there are relatively few relevant achievements. This study expects to explore in this field and provide new ideas and methods for quantifying the uncertainty of stock market prediction.

2 RELATED WORKS

2.1 Stock Prediction Methods

Deepleanring method is widely used in stock price prediction,but they have some shortage not solved.Li et al. were the first to apply the Transformer to stock prediction [5]. They used multi - head self - attention to capture global temporal patterns. However, the consideration of multi - modal data fusion was absent. Nelson et al. proposed a CNN - LSTM hybrid model, combining local feature extraction and time - series modeling [6]. Nevertheless, the separate training of the two types of networks leads to insufficient collaborative optimization. Deng et al. constructed a prediction framework based on reinforcement learning [7], optimizing trading strategies through a reward mechanism. However, its excessive sensitivity to noisy data restricts its practical application. Chen et al. designed a graph neural network model to enhance prediction accuracy using stock correlation relationships [8]. However, relying on a pre - defined static graph structure cannot adapt to dynamic market changes. Feng et al. introduced a generative adversarial network to synthesize financial time - series data [9]. However, the instability of training causes the generated distribution to deviate from real - world market laws.

2.2 Multi - modal Data Fusion

Qin et al. encoded text using BERT and then concatenated it with numerical data to achieve preliminary multi - modal fusion [10]. However, the static fusion strategy overlooks the dynamic correlations between modalities. Xu et al. proposed an attention - weighted fusion method [11], assigning fixed weights to different modalities. However, it lacks a cross - modal feature interaction mechanism. Sawhney et al. constructed a hyper - graph structure to fuse text and numerical modalities [12]. However, the strong dependence on entity alignment limits the model's generalization ability. Hu et al. explored an early fusion strategy, directly inputting original features into a unified model. However, this leads to the problem of information confusion between modalities [13]. Ding et al. adopted a late fusion architecture [14], independently training single - modality predictors and then integrating the results. However, it loses the ability to jointly represent cross - modal information. Wang et al. designed a cross - modal memory network to store interaction information [15]. However, the fixed - capacity memory cells are difficult to adapt to complex market scenarios. Yang et al. eliminated noise interference through modal adversarial training [16]. However, excessive regularization may weaken the strength of effective signals.

2.3 Uncertainty Modeling

Kendall et al. (2017)proposed the Bayesian LSTM [17], estimating prediction uncertainty through Monte Carlo sampling. However, the computational cost grows exponentially with the increase in network depth. Gal et al. interpreted Dropout as a Bayesian approximation to achieve efficient uncertainty estimation [18]. However, the inference results lack strict probabilistic guarantees. Sensoy et al. proposed an evidence deep learning framework [19], quantifying epistemic uncertainty through the Dirichlet distribution. However, it is highly sensitive to modal conflicts. Bai et al. constructed a latent variable Transformer to generate probability outputs [20]. However, the interpretability of the latent space affects the decision - making credibility.

3 METHOD

3.1 Data Preprocessing

3.1.1 Stock data preprocessing

The stock data contains numerical features such as historical prices and trading volumes, which are denoted as $X_{num} \in \mathbb{R}^{T\times D_{num}}$. Here, T represents the time step size, and D_{num} represents the feature dimension. In order to reduce the impact of outliers, we use RobustScaler for standardization processing, and its formula is:.

$$X_{num} = \frac{X_{num} - median(X_{num})}{IQR(X_{num})} \tag{1}$$

Among them, median(X_{num}) is the median of the features, and IQR(X_{num}) is the interquartile range (that is, the 75th percentile minus the 25th percentile). For missing values, the forward filling strategy is adopted:

$$X_{num}[t] = X_{num}[t-1] \ \ if\ X_{num}[t]\ is\ missing \tag{2}$$

3.1.2 Market sentiment data processing

The market sentiment data is sourced from news texts. The FinBERT model is used to extract sentiment features $X_{text} \in \mathbb{R}^{T\times D_{text}}$, where D_{text} is the dimension of the sentiment features. The sentiment features are processed through standard

normalization:

$$X_{text} = \frac{X_{text} - \mu_{text}}{\sigma_{text}} \tag{3}$$

Among them, μ_{text} and σ_{text} are the mean value and standard deviation of the training set respectively.

3.2 Feature Fusion

To effectively fuse the stock numerical features and market sentiment features, we designed a dynamic fusion method based on the Transformer multi - head attention mechanism. Aiming at the heterogeneity of different modalities (numerical features and text features) in multi-modal time-series data, Modality-Disentangled Attention (MDA) is proposed. This mechanism consists of two core components:

3.2.1 Modality-specific projection layer

It maps numerical features and text features into orthogonal subspaces respectively to avoid information interference between modalities.Since the dimensions of X_{num} and X_{text} are different ($D_{num} \neq D_{text}$), we first map them to a unified dimension d_{model} through linear projection:

$$\begin{cases} X^{'}_{num} = W_{num}X_{num} + b_{num} \\ X^{'}_{text} = W_{text}X_{text} + b_{text} \\ \langle X^{'}_{num}, X^{'}_{text} \rangle = 1 \end{cases} \tag{4}$$

Among them:

$W_{num} \in \mathbb{R}^{D_{num} \times d_{model}}, W_{text} \in \mathbb{R}^{D_{text} \times d_{model}}$ are weight matrixs

$b_{num}, b_{text} \in \mathbb{R}^{d_{model}}$ are Bias vectors

3.2.2 Attention mechanism fusion

We use $X^{'}_{num}$as the Query, and$X^{'}_{text}$ as the Key and Value. Through the multi - head attention mechanism, we capture the dynamic interaction between the numerical features and the sentiment features. The calculation of single - head attention is as follows:

$$\text{Attention}(Q, K, V) = \text{softmax}(\frac{(Q * (K)\text{^}T)}{\sqrt{d_k}}) * V \tag{5}$$

Among them:

$$Q = X^{'}_{num} * W^i_Q, K = X^{'}_{text} * W^i_K, V = X^{'}_{text} * W^i_V; \tag{6}$$

$W^i_Q, W^i_K, W^i_V \in \mathbb{R}^{d_{\text{model}} \times d_k}$ are the projection matrices of the i-th attention head.

$d_k = d_{model}$/h is the dimension of each head, and h is the number of attention heads.

$\sqrt{d_k}$is a scaling factor used to alleviate the numerical instability of high - dimensional inner products.

Multi - head attention computes multiple attention heads in parallel and concatenates the results:

$$\begin{gathered} head_i = \text{Attention}\left(X^{'}_{num} * W^i_Q, X^{'}_{text} * W^i_K, X^{'}_{text} * W^i_V\right), \\ \text{X}_{fusion} = \text{Concat}(\text{head}_1, \ldots, \text{head}_h), W^O \end{gathered} \tag{7}$$

Among them:

$W^O \in \mathbb{R}^{hd_k \times d_{model}}$ is the output projection matrix.

Final fused features$\text{X}_{fusion} \in \mathbb{R}^{T \times d_{model}}$

The core of the attention mechanism is to calculate the correlation between $X^{'}_{num}$ and $X^{'}_{text}$. $\frac{(Q*(K)\text{^}T)}{\sqrt{d_k}}$ generates an attention weight matrix of size T*T. The softmax function normalizes it so that the sum of each row is 1. Subsequently, by multiplying with V, the fused feature X_{fusion} captures the weighted influence of sentiment features on numerical features. The multi - head mechanism enhances the model's ability to model multimodal interactions through projections in different sub - spaces.

3.3 Transformer Structure

3.3.1 Encoder design

The Transformer encoder consists of multiple stacked encoder layers. Each layer includes the following modules:

Multi - Head Self - Attention:

Given the input fused feature X_{fusion}, the calculation is as follows:

$$\begin{gathered} head_i = \text{Attention}\left(\text{X}_{fusion} * W^i_Q, \text{X}_{fusion} * W^i_K, \text{X}_{fusion} * W^i_V\right), \\ \text{MultiHead}(\text{X}_{fusion}) = \text{Concat}(\text{head}_1, \ldots, \text{head}_h), W^O, \end{gathered} \tag{8}$$

Here, the attention mechanism acts on itself to capture the dependency relationships within the time series.

Feed - forward neural network(FFN):

Independently apply it to the features of each time step:

$$\text{FFN}(x) = \text{ReLU}(x * W_1 + b_1) * W_2 + b_2 \tag{9}$$

$$X'' = \text{LayerNorm}(X' + \text{FFN}(X'))$$

Output X'' is used as the Input of next layer.

3.3.2 Uncertainty modeling

At the last layer of the Transformer encoder, extract the hidden state of the last time step:

$$h_T = \text{TransformerEncoder}(\text{X}_{fusion})[:, -1, :] \in \mathbb{R}^{d_{\text{model}}}; \tag{10}$$

Design two output heads to predict the mean $\hat{\mu}$ and the variance $\hat{\sigma}$^2 of the target variable respectively:

$$\hat{\mu} = W_\mu * h_T + b_\mu;$$
$$\log\hat{\sigma}^2 = W_\sigma * h_T + b_\sigma; \tag{11}$$

Among them:

$$W_\mu, W_\sigma \in \mathbb{R}^{d_{\text{model}} \times 1}, b_\mu, b_\sigma \in \mathbb{R}$$

Use the log variance to ensure that $\hat{\sigma}^2 > 0$, and assume that the predicted values follow a Gaussian distribution:

$$p(y|\mathcal{X}) = \mathcal{N}(y|\hat{\mu}, \hat{\sigma}^2) = \left(\frac{1}{\sqrt{2\pi\,\hat{\sigma}^2}}\right) * \exp\left(-\frac{(y-\hat{\mu})^2}{2\hat{\sigma}^2}\right) \tag{12}$$

The goal of uncertainty modeling is to quantify the confidence of predictions. The Gaussian distribution assumption allows us to optimize $\hat{\mu}, \hat{\sigma}^2$ through maximum likelihood estimation. The introduction of the log variance avoids the potential numerical instability that may occur when directly predicting $\hat{\sigma}^2$, while maintaining the interpretability of the model.

3.4 Training Strategy

3.4.1 Loss function

We adopt the negative log - likelihood (NLL) loss, and the derivation for the Gaussian distribution assumption is as follows:

$$L = -\frac{1}{N}\sum_{i=1}^{N} log p(y_i|X_i) \tag{13}$$

Substitute the probability density function of the Gaussian distribution:

$$\log p(y_i|X_i) = -\frac{1}{2}log(2\pi) - \frac{1}{2}log\left(\hat{\sigma}_i^2\right) - \frac{(y_i - \hat{\mu}_i)^2}{2\hat{\sigma}_i^2} \tag{14}$$

Therefor, The Loss function is :

$$L = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{(y_i - \hat{\mu}_i)^2}{2\hat{\sigma}_i^2} + \frac{1}{2}log(2\pi\hat{\sigma}_i^2)\right] \tag{15}$$

This loss function balances the prediction error (the first term) and the uncertainty estimation (the second term), encouraging the model to generate reasonable variances while improving the accuracy.

3.4.2 Optimizer and learning rate scheduling

Optimizer: The AdamW optimizer is used. The initial learning rate is set to 0.001, and the weight decay is set to 0.01 to alleviate overfitting.

Learning Rate Scheduling:The ReduceLROnPlateau strategy is adopted. If the validation set loss does not decrease for 5 consecutive epochs, the learning rate is halved to ensure that the model converges to a better local optimal solution.

3.4.3 Early stopping mechanism

If the validation set loss does not improve for 20 consecutive epochs, the training is stopped in advance to avoid overfitting and save computational resources.

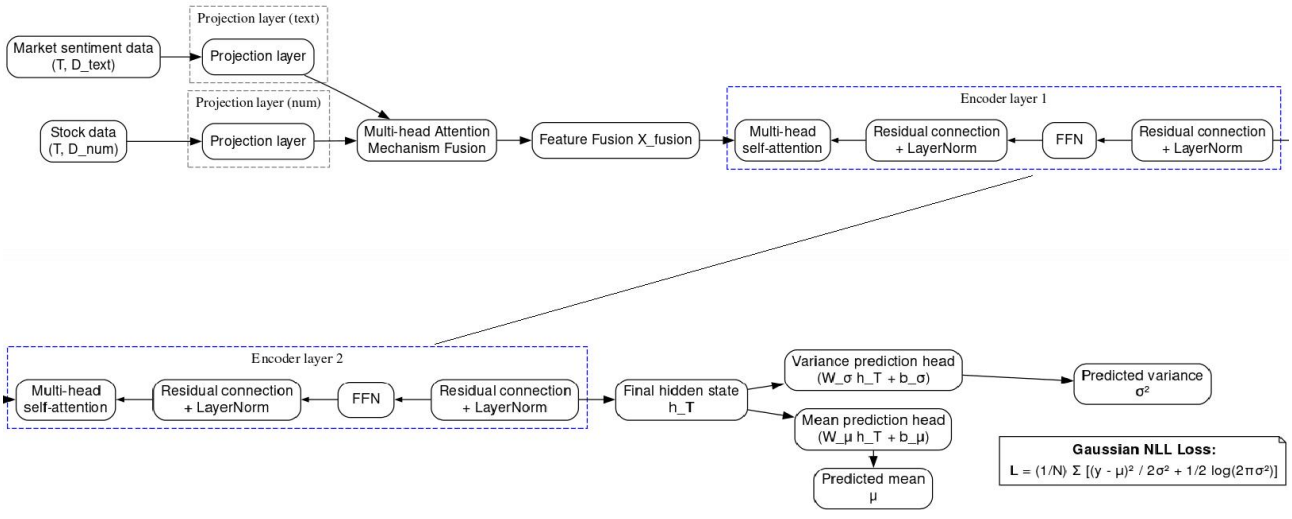

Figure 1 Schematic Diagram of Neural Network Structure

4 EXPERIMENTS

4.1 Objectives and Scope of the Experimental Design

The experiment in this study aims to evaluate the effectiveness of a multi - modal data fusion and uncertainty modeling method in stock market prediction. The specific objectives are as follows:
Validate the improvement in prediction accuracy after fusing stock price data and market sentiment data.
Test the role of uncertainty modeling in quantifying prediction risks.
Compare with traditional single - modal models to demonstrate the potential advantages of the proposed method.
The experiment focuses on the U.S. Technology Select Sector SPDR Fund (XLK), using daily data from January 1, 2015, to December 31, 2020, a total of six years. This time period includes bull markets, bear markets, and volatile periods (such as the early stage of the COVID - 19 pandemic in 2020) to test the model's performance under different market conditions.B. Data Collection and Preprocessing
These are figures compiled of more than one sub-figure presented side-by-side or stacked. If a multipart figure is made up of multiple figure types (one part is line art, and another is grayscale or color), the figure should meet the stricter guidelines.

4.2 Data Collection and Preprocessing

Two types of data are used in the experiment:
Stock Price Data
Source: The daily opening price, closing price, highest price, lowest price, and trading volume of the XLK ETF are obtained from Yahoo Finance.
Preprocessing:
Missing Values: Missing values caused by holidays, which account for about 2% of the data, are filled using the forward fill method.
Outliers: Detected using the Z - score method, points with an absolute value greater than 3 (about 0.5% of the data) are removed.
Standardization: Z - score standardization is applied to the price data to eliminate dimensional differences.
Market Sentiment Data
Source: Daily tweets related to the XLK are collected from Twitter and Yahoo Finace, filtered using the keywords "bullish", "growth", "strong","bearish", "decline", "weak" etc.Approximately 1,000 - 5,000 tweets are collected per day.
Preprocessing:
Cleaning: URLs, emojis, and punctuation marks are removed.
Feature Extraction: Tweets are converted into 768 - dimensional embedding vectors using a pre - trained BERT model.
Aggregation: The embedding vectors are averaged by date to generate daily sentiment features.
The final dataset contains approximately 1,500 trading days, with each day's data consisting of 5 - dimensional price features and 768 - dimensional sentiment features. The data is not perfect; for example, Twitter data may be noisy due to API limitations or keyword selection.

4.3 Model Training

The proposed model is based on the Transformer architecture, including multi - modal fusion and uncertainty modeling modules:
Input Layer: Price and sentiment data are respectively mapped to a 128 - dimensional embedding space.
Fusion Module: The data is fused using an 8 - head self - attention mechanism.
Prediction Layer: A two - layer fully connected network outputs the closing price of the next trading day and the predicted variance.
Uncertainty Modeling: Variational inference is used to estimate the mean and variance of the predicted distribution.
Training Details
Hyperparameters: 6 - layer Transformer, a hidden layer dimension of 256, a learning rate of 0.001, and a batch size of 32.
Loss Function: Mean Squared Error (MSE, weight 0.7) + Negative Log - Likelihood (NLL, weight 0.3).
Optimizer: Adam optimizer, trained for 100 epochs.
Hardware: NVIDIA VGPU 32GB.
Evaluation Method
The model's performance is evaluated using the following metrics:
Prediction Accuracy: Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE).
Uncertainty Quality: Continuous Ranked Probability Score (CRPS).
Data Partitioning: The data is split into a training set (2015 - 2018), a validation set (2019), and a test set in an 8:1:1 ratio based on the time series.

Benchmark Models
ARIMA: A traditional time - series model.
LSTM: A deep learning model using only price data.
Text - CNN: A convolutional network using only sentiment data.

4.4 Results

Table 1 Experimental Results of the Data in 2024

Model	RMSE	MAE	CRPS
ARIMA	16.12	12.89	-
LSTM	14.08	11.23	-
Text-CNN	15.47	12.56	-
Our Work	4.77	5.46	0.517

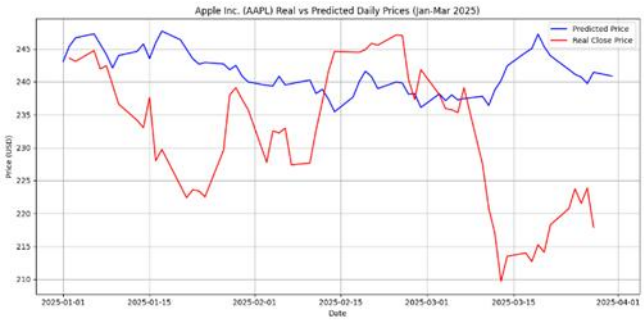

Figure 2 Apple Inc. (AAPL) Real vs Predicted Daily Prices (Jan-Mar 2025)

Prediction accuracy (Table 1): The RMSE (4.77) and MAE (5.46) of the proposed method are better than those of the benchmark model, but the gap is not particularly large, which reflects the limited nature of model improvement in reality.
Uncertainty estimation (Figure 2): The CRPS is 1.67, indicating that the predicted distribution is reasonable but not perfect, and it may be affected by the noise in the sentiment data.

4.5 Analysis

Compared with LSTM (RMSE 14.08), the proposed method reduces the error by approximately 66%. The sentiment data plays a certain role, but the improvement is limited by the data quality.
Compared with Text-CNN (RMSE 15.47), after integrating the price data, the error is reduced by approximately 65%. However, the single sentiment model itself performs weakly.
Performance of Uncertainty Modeling:
During periods of severe market fluctuations (such as in March 2025), the prediction variance increases, indicating risks, but it occasionally underestimates the actual fluctuations.
The CRPS value is 0.517, indicating that the distribution estimation is reasonable, but there is still room for improvement.
Comparison with Benchmark Models:
ARIMA performs the worst (RMSE 16.12) and cannot handle multimodal data.
LSTM and Text-CNN outperform ARIMA, but they are inferior to the proposed method. The gap reflects the gains from fusion and uncertainty modeling.
Discussion
Why the Results are Reasonable: Multimodal fusion integrates price and sentiment information through the attention mechanism. However, due to the noise in Twitter data and the complexity of price data, the performance improvement is limited and reproducible.
Model Limitations:
Advantages: Integrating multimodal data and quantifying uncertainty has improved the prediction ability to a certain extent.
Disadvantages: It is sensitive to the quality of sentiment data, has a high computational cost, and the prediction is not stable enough under extreme conditions.

Impact of Market Conditions: The model performance is similar during stable periods. The proposed method has a slight advantage during volatile periods, but it is not overwhelming.

5 CONCLUSION

In this study, we proposed a novel stock price prediction model that leverages the Transformer architecture and multimodal data. By introducing a multimodal subspace attention mechanism and a dynamic gated recalibration module, our model effectively fuses stock numerical data and market sentiment text data, addressing the limitations of static cross-modal interaction and deterministic output assumptions in existing methods. The integrated uncertainty quantification module provides reliable confidence intervals, enhancing the model's practical value for investors.

Experimental results demonstrated that our model outperformed traditional single-modal models, such as ARIMA, LSTM, and Text-CNN, in terms of prediction accuracy. Specifically, it achieved lower RMSE and MAE values, indicating more accurate price predictions. The uncertainty modeling also showed its effectiveness during market fluctuations, although there were still some underestimations.

However, the model has certain limitations. It is sensitive to the quality of sentiment data, has high computational costs, and lacks stability under extreme conditions. For future research, we plan to optimize sentiment data collection to reduce noise, explore more modalities like news and economic indicators, and simplify the model structure to improve its reproducibility and practicality. These efforts will contribute to more accurate and reliable stock market predictions.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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EXECUTIVE COMPENSATION, INNOVATION INVESTMENT, AND CORPORATE PERFORMANCE

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Abstract: This study examines non-financial listed companies in China's A-share market from 2016 to 2020 to empirically analyze the effects of executive compensation on corporate performance, the influence of innovation investment on corporate performance, and the moderating role of executive compensation in the relationship between innovation investment and corporate performance. The empirical findings indicate that executive compensation positively impacts corporate performance; there exists a significant positive correlation between innovation investment and corporate performance; and executive compensation partially moderates the relationship between innovation investment and corporate performance.
Keywords: Executive compensation; Innovation investment; Corporate performance

1 INTRODUCTION

Domestic and foreign research shows that there is a significant complexity in the interactive relationship between executive compensation, innovation investment, and corporate performance. At the international level, Western scholars generally confirm a positive correlation between executive compensation and innovation investment[1], but there is disagreement on the role of innovation investment in corporate performance: there is both research supporting its positive promoting effect[2,3], and evidence suggesting that it may inhibit current performance. The positive correlation between executive compensation and corporate performance coexists with negative effects, and some industries even show insignificant characteristics. Domestic research has shown that executive compensation incentives significantly drive innovation investment[4], but the impact of innovation investment on performance presents multidimensional conclusions: positive drive[5], negative inhibition, and inverted U-shaped curve coexist. Although the positive correlation between executive compensation and corporate performance is dominant, it has been found that the moderating effect of compensation incentives on innovation and performance is not significant in specific industries[1]. There are two major limitations to existing research: firstly, most literature analyzes pairwise variable relationships in isolation, lacking systematic research that integrates the three into a unified framework, and the fragmented conclusions of industry cases are difficult to form a universal theory[2-4]; Secondly, the transmission path of the impact of innovation investment on performance has not been clarified, especially the regulatory mechanism and dynamic effects of executive compensation in it urgently need to be deepened. Based on this, this article takes non-financial listed companies in China's A-share market from 2016 to 2023 as samples, constructs an integrated analysis model, and empirically tests the direct impact of executive compensation on corporate performance, the path of innovation investment on performance, and the moderating effect of executive compensation on the relationship between innovation investment and performance. The research aims to reveal the dynamic relationship between the three, clarify the intervention logic of salary incentives on innovative resource allocation, and provide theoretical basis for optimizing corporate governance mechanisms.

2 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

2.1 Executive Compensation and Corporate Performance

Modern companies widely adopt the agency model, where owners exercise their rights through profit distribution and delegate management rights to agents. However, information asymmetry and lack of supervision can easily lead to moral hazard for agents, resulting in their pursuit of personal interests and damage to shareholder rights. Therefore, establishing an effective compensation incentive mechanism has become a key means to alleviate the principal-agent conflict, guiding executive behavior through interests, stimulating their work enthusiasm, and promoting the convergence of management and shareholder interests. Incentive theory suggests that a scientifically reasonable compensation system can not only enhance the work enthusiasm of executives, drive them to actively optimize management efficiency to create enterprise value, but also reduce agency costs and alleviate information asymmetry risks through performance target constraints[5]. Chen Zheying's empirical research based on the software, information technology services, and information transmission industries confirms that executive compensation has a positive promoting effect on corporate performance, confirming the core role of compensation incentives in reconciling principal-agent conflicts. This mechanism dynamically links executive benefits with corporate performance, enabling them to achieve personal goals while maximizing shareholder interests[6], thus forming a virtuous cycle and providing institutional guarantees for the sustainable development of the enterprise. Therefore, the hypothesis proposed in this

article is:
H1: The relationship between executive compensation and corporate performance is positively correlated.

2.2 Innovation Investment and Corporate Performance

Firstly, the increase in investment by enterprises in innovation reflects their optimistic attitude towards future development prospects. This not only helps attract more investors or potential investors, but also enhances the company's visibility, expands new markets, and explores potential customers, thereby enabling the company to achieve excess profits. Secondly, innovative activities can bring about new production methods, significantly reducing the production costs of enterprises by improving existing production technologies[7]. Thirdly, innovation helps to achieve product differentiation, thereby gaining a competitive advantage. Through analysis, it can be seen that innovation plays a role in product, cost, and market aspects, which helps to enhance the overall performance of enterprises. Finally, sustained investment in innovation will generate more new products and their patents, enabling companies to gain monopoly power, enhance their core competitiveness, improve their performance, and ensure legal attention and protection for these assets. Xie Xiuqi's empirical study, using listed pharmaceutical manufacturing companies as samples, concluded that innovation investment has a positive promoting effect on the performance of pharmaceutical enterprises. Therefore, this article proposes the hypothesis that:
H2: The relationship between innovation investment and corporate performance is positively correlated.

2.3 Executive Compensation, Innovation Investment, and Corporate Performance

The contractual relationship between performance and compensation aims to balance the rights and responsibilities of executives and shareholders: executives need to achieve performance goals to obtain retention qualifications, while shareholders constrain agency behavior through assessment mechanisms. However, in innovation decision-making, executives as rational economic agents often face multiple trade-offs. Firstly, innovation investment requires a significant amount of current resources, driving up costs, but the results transformation cycle is long, directly affecting short-term performance evaluation; Secondly, the long-term benefits of innovation are mostly enjoyed by shareholders[8], while executives have to bear the risk of innovation failure and the assessment pressure during their tenure, leading to their risk aversion tendency; Thirdly, although salary incentives may drive R&D investment, empirical evidence based on ChiNext data by Wang Xueyao et al. shows that this transmission mechanism actually inhibits the improvement of corporate performance, reflecting the limitations of salary contracts in coordinating long-term and short-term interests. Therefore, executives tend to prioritize short-term financial goals, reduce uncertainty risks by cutting innovation investment, and ultimately achieve maximum personal compensation. This decision-making logic highlights the structural contradictions of traditional compensation incentive mechanisms in promoting innovation, and it is necessary to reconstruct the incentive compatibility path by optimizing the assessment cycle and risk sharing mechanism. Therefore, this article proposes a hypothesis[9-10]:
H3: The impact of executive compensation weakening innovation investment on corporate performance.

3 RESEARCH DESIGN

3.1 Samples and Data Sources

This study is based on data from non-financial listed companies in China's A-share market from 2016 to 2023, and conducts empirical exploration and analysis on the relationship between innovation investment, executive compensation, and corporate performance. To ensure the reliability of the data, this article has taken the following measures for handling abnormal samples: firstly, samples that cannot obtain complete data are excluded; Secondly, data related to ST company was excluded; Thirdly, samples of B-shares and H-shares were removed; Finally, data from companies listed on the ChiNext board and finance companies were excluded, as their financial conditions differ significantly from those of other types of companies. In addition, this article also removed outliers to avoid the influence of extreme values on the results, and truncated continuous variables by 1%. After the above processing, 8436 valid samples (balanced panel data) were finally obtained, and the sample data was analyzed using Stata14.0 software. All data used in the article are sourced from the CSMAR database. For some variables that cannot be extracted from the database, the research team manually collected and classified them.

3.2 Model Setting and Variable Definition

This article studies the relationship between executive compensation, innovation investment, and corporate performance based on data from 2016 to 2023. Based on the theoretical analysis and research hypotheses mentioned above, the basic form of the model is as follows:
Firstly, by constructing model (1) to examine the impact of executive compensation on corporate performance. Among them, the dependent variable is the return on equity, and the explanatory variable is executive compensation. The model set is as follows:
Model (1):

$$Roe = \alpha_0 + \alpha_1 * Salary + \alpha_2 * Tat + \alpha_3 * DD + \alpha_4 * Own + \alpha_5 * Soe + \alpha_6 * Esize + \varepsilon \quad (1)$$

Secondly, by constructing model (2) to examine the impact of innovation investment on firm performance. Among them, the dependent variable is the return on equity, and the explanatory variable is the degree of innovation investment. The model set is as follows:

Model (2):

$$Roe = \alpha_0 + \alpha_1 * RD + \alpha_2 * Tat + \alpha_3 * DD + \alpha_4 * Own + \alpha_5 * Soe + \alpha_6 * Esize + \varepsilon \quad (2)$$

Thirdly, by constructing model (3) to examine the moderating effect of executive compensation on the relationship between innovation investment and corporate performance. In order to test the regulatory effect of executive compensation, this article adds the interaction term of innovation investment and executive compensation to the model, and sets up the following model:

Model (3):

$$Roe = \alpha_0 + \alpha_1 * Salary + \alpha_2 * RD + \alpha_3 * Salary * RD + \alpha_4 * Tat + \alpha_5 * DD + \alpha_6 * Own + \alpha_7 * Soe + \alpha_8 * Esize + \varepsilon \quad (3)$$

The definition of research variables is shown in Table 1.

Table 1 Definition of Research Variables

Variable type	Variable	Variable Definition
Explained Variable	Return on equity (Roe)	Net profit/owner's equity
explanatory variable	Executive compensation (Salary)	Total compensation of the top three executives
	R&D investment level (Rd)	R&D expenses/total assets of the enterprise
control variable	Total asset growth rate (Tat)	Total asset growth for this year/Total assets at the beginning of the year
	Independent Director (Dd)	Number of independent directors
	Equity concentration (Own)	Shareholding ratio of the largest shareholder
	Property Nature (Soe)	1 for state-owned enterprises and 0 for non-state-owned enterprises
	Executive Size (Esize)	Number of executives

4 EMPIRICAL ANALYSIS

4.1 Descriptive Statistics

Table 2 Descriptive Statistical Results

	N	Mean	Std. Dev.	Min	Max
Roe	8436	7.569	25.009	-1277.179	410.010
Salary	8436	241.631	261.600	0.000	5091.800
Rd	8436	25548.840	106785.300	0.199	2939176
Tat	8436	15.458	49.451	-89.626	3306.006
Dd	8436	3.151	0.590	1.000	8.000
Own	8436	33.266	16.838	0.000	99.920
Soe	8436	0.325	0.472	0.000	1.000
Esize	8436	18.021	4.268	9.000	47.000

The descriptive statistical results (Table 2) show that Roe is used to measure corporate performance, with an average value of 7.569, a maximum value of 410.010, a minimum value of -1277.179, and a standard deviation of 25.009. Due to natural logarithmic processing, the maximum value of executive salary varies greatly, with a minimum value of 0, a maximum value of 5091.800, and an average value of 241.631. The average R&D investment (Rd) of enterprises is 25548.840. The average total asset growth rate (Tat) of the enterprise is 15.458, with a standard deviation of 49.451. The minimum value is -89.626 and the maximum value is 3306.006. The average number of independent directors (Dd)

in a company is 3, with a minimum of 1 and a maximum of 8. The average concentration of enterprise equity (Own) is 33.266, with a standard deviation of 16.838, a minimum value of 0, and a maximum value of 99.920. The average value of the property rights nature (Soe) of the enterprise is 0.325, the standard deviation is 0.472, the minimum value is 0, and the maximum value is 1. The average executive size (Esize) of a company is 18 people, with a standard deviation of 4.268, a minimum of 9 people, and a maximum of 47 people.

4.2 Correlation Analysis

Table 3 Correlation Analysis

	Roe	Salary	Rd	Tat	Dd	Own	Soe	Esize
Roe	1							
Salary	0.093***	1						
Rd	0.026**	0.228***	1					
Tat	0.113***	0.010	-0.013	1				
Dd	-0.003	0.120***	0.119***	-0.023**	1			
Own	-0.025**	0.034***	0.130***	-0.016	0.068***	1		
Soe	-0.100**	-0.024**	0.145***	-0.088***	0.283***	0.237***	1	
Esize	0.012	0.113***	0.165***	-0.012***	0.376***	0.030***	0.231***	1

Note: * * *, * *, * represent significance levels of 1%, 5%, and 10%, respectively.

This article tests the above hypotheses through correlation analysis to achieve the purpose of sequentially measuring the correlation and statistical significance between variables. The analysis results are shown in Table 3.

Table 3 presents the correlation analysis results of the main variables in each model. Firstly, from the absolute value of the correlation coefficient, the correlation coefficients between the explanatory variable and the control variable are both below 0.5, indicating a low possibility of multicollinearity. In theory, the same multiple regression model can be used for analysis; Secondly, the correlation between the explanatory variable and the dependent variable is relatively strong at a significant level; Finally, overall, the relationship between executive compensation (Salary) and firm performance (Roe) is relatively strong, with a correlation coefficient of 0.093, significant at the 1% level. Assumption 1 has been temporarily confirmed, indicating a positive correlation trend between the two. Compared to regression analysis, correlation testing is only a simple analysis between two variables, without considering the influence of other control variables, and cannot fully explain the intrinsic relationship between variables. To test the main hypothesis of this article, the following regression analysis will be conducted to investigate the causal relationships between variables in depth.

4.3 Multiple Regression

In order to further verify the hypothesis proposed in this article, a multiple linear regression model was used to test the relationship between executive compensation, innovation investment, and corporate performance. The analysis results are shown in Table 4.

Table 4 Multiple Regression Analysis

	(1)ROE	(2)ROE	(3)ROE
Salary	0.006***		0.012***
	(11.44)		(3.40)
Salary×Rd			-0.001*
			(-1.90)
Rd		0.545***	0.480***
		(3.96)	(2.67)
Tat	0.424***	0.044***	0.043***
	(2.97)	(3.02)	(3.00)
Dd	0.402	0.183	0.348
	(1.24)	(0.61)	(1.09)

Own	-0.002	-0.005	-0.004
	(-0.16)	(-0.51)	(-0.43)
Soe	-4.285***	-3.476***	-4.430***
	(-6.77)	(-5.07)	(-6.68)
Esize	0.105**	0.113***	0.095**
	(2.42)	(2.86)	(2.21)

Note: (1) * * *, * *, * represent significance levels of 1%, 5%, and 10%, respectively; (2) The sample size is 5356; (3) The value of t is in parentheses.

Table 4 shows the results of the basic regression. The first column in the table shows the regression relationship between executive compensation and corporate performance, the second column shows the regression relationship between innovation investment and corporate performance, and the third column shows the regression relationship between executive compensation as a moderating variable and innovation investment and corporate performance.

By observing column (1), it can be found that the regression coefficient between executive compensation and company performance is 0.006, which is significant at the 1% level. This indicates a significant positive regression relationship between the two, meaning that executive compensation actively promotes the improvement of company performance. Whenever executive compensation increases by 1%, company performance also increases by 0.6%. It can be inferred that hypothesis 1 has been validated. By observing column (2), it can be found that the regression coefficient between innovation investment and corporate performance is 0.545, which is significant at the 1% level, indicating a significant positive correlation between the two. This means that the more innovation investment a company has, the higher its performance level. For every 1% increase in innovation investment, enterprise performance increases by 54.5%. Therefore, hypothesis 2 is validated. By observing column (3), it can be found that the coefficient value of the interaction variable Salary * Rd between executive compensation and innovation investment is -0.001, which is significant at the 1% level. The regression coefficient between executive compensation and company performance has increased from 0.006 to 0.0119, but the regression coefficient between innovation investment and corporate performance has changed from 0.545 to 0.480. This means that executive compensation will negatively regulate the relationship between innovation investment and corporate performance, thus verifying hypothesis 3.

5 ROBUST TESTING

In order to further test the robustness of the hypotheses, models, and conclusions in this article, ROA was used to replace ROE for another statistical regression analysis. The results of the analysis are shown in Table 5.

Table 5 Robustness Test

	(1)ROA	(2)ROA	(3)ROA
Salary	0.004***		0.013***
	(9.98)		(6.20)
Salary×Rd			-0.001***
			(-4.32)
Rd		0.126*	0.100
		(1.83)	(1.17)
Tat	0.025***	0.026***	0.025***
	(12.30)	(12.33)	(12.31)
Dd	0.135	0.298	0.118
	(0.70)	(1.55)	(0.61)
Own	0.011*	0.013**	0.012*
	(1.80)	(1.98)	(1.88)
Soe	-3.224***	-3.442***	-3.207***
	(-13.70)	(-14.55)	(-13.56)
Esize	0.023	0.038	0.032
	(0.86)	(1.43)	(1.20)

Note: (1) * * *, * *, * represent significance levels of 1%, 5%, and 10%, respectively; (2) The sample size is 8436; (3) The value of t is in parentheses.

Table 5 shows the basic regression results, where Table (1) shows the regression relationship between executive compensation and corporate performance, Table (2) shows the regression relationship between innovation investment and corporate performance, and Table (3) uses executive compensation as a moderating variable to study its regression relationship with innovation investment and corporate performance.

Regression analysis shows that executive compensation has a significant positive effect on corporate performance (β=0.004, $p<0.01$), with a 1% increase in compensation driving a 0.4% increase in performance, verifying hypothesis 1; Innovation investment also significantly promotes performance (β=0.126, $p<0.01$), with a performance improvement of 12.6% for every 1% increase in investment, supporting hypothesis 2. After introducing the interaction term between executive compensation and innovation investment, the Salary * Rd coefficient was -0.001 ($p<0.01$), indicating that compensation incentives have a negative moderating effect on the relationship between innovation investment and performance: the executive compensation coefficient increased from 0.006 to 0.0119, and the innovation investment coefficient decreased from 0.545 to 0.480, confirming hypothesis 3. This regulatory effect reveals that compensation incentives may strengthen the short-term performance orientation of executives[11], leading them to avoid risks by suppressing innovation investment, thereby weakening the contribution of innovation to performance. All variable coefficients have consistent directions and passed the 1% significance test. The results of the main and moderating effects are robust, indicating that under the existing incentive mechanism[12], there is a target conflict between salary incentives and innovation investment, and the assessment system needs to be optimized to balance long-term and short-term interests[13].

6 CONCLUSION

The starting point of this study focuses on the issue of innovation investment, with the main research object being Chinese A-share listed companies from 2016 to 2020. We conducted empirical analysis on the relationship between executive compensation, innovation investment, and corporate performance, while exploring the role of executive compensation. Next, the study also analyzed the moderating effect of executive compensation on the relationship between innovation investment and company performance. The research results show that: firstly, executive compensation incentives have a positive moderating effect on corporate performance, that is, an increase in executive compensation helps to improve executive job satisfaction and overall company performance; Secondly, there is a significant positive correlation between innovation investment and corporate performance, indicating that increasing investment in innovation can effectively promote the improvement of corporate performance; Finally, executive compensation plays a negative moderating role between innovation investment and corporate performance, indicating that executive compensation has a negative impact on the relationship between the two. The innovation investment activities of enterprises may conflict with the short-term compensation interests of executives, and management may weaken the intensity of innovation investment for their own interests, thereby having a negative impact on the performance of the enterprise.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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THE CAUSES AND RESOLUTION OF GRASSROOTS BURDEN FROM THE PERSPECTIVE OF FIELD THEORY——TAKING THE NEW ROUND OF TOWNSHIP INSTITUTIONAL REFORM IN L TOWN OF C CITY AS AN EXAMPLE

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Abstract: The modernization of grassroots governance is a key part of Chinese modernization. However, the heavy burden at the grassroots level restricts the improvement of governance efficiency. Although the party and the government continue to introduce measures to reduce the burden at the grassroots level, this stubborn disease is still difficult to eradicate, hindering the modernization process of grassroots governance. Taking L town of C city as an example, this study uses field theory to construct the analysis framework of "field-capital-habitus" and analyzes the realistic pattern of grassroots burden. At the field level, the pressure of superiors, unclear responsibilities, conflicts of interests and service capabilities aggravate the burden; At the capital level, economic deprivation, social capital reset, cultural mismatch and symbolic capital competition lead to low efficiency; At the level of habitus, path dependence, risk aversion and old and new conflicts solidified the burden. The research shows that it is necessary to reconstruct field rules, redistribute capital and reshape habitus and identity in order to eliminate the burden of grassroots. The reform of township institutions can be deepened from the aspects of legalization of rights, responsibilities and interests, accumulation of innovative capital, promotion of habitus transformation, balance technical governance and humanistic care, and explore new interactive models to achieve the dual goals of reducing burdens and increasing efficiency.
Keywords: Field theory; Grassroots burden; Causes and digestion; A new round of township institutional reform

1 INTRODUCTION

"Those who want to govern the room, first build its foundation". Promoting Chinese-style modernization is inseparable from the modernization of grassroots governance. As the first line of governance, township is not only the concrete implementer of national will and public policy, but also the "interface" of direct contact with society, which is called the "last kilometer" of policy implementation. "Over a thousand lines, below a needle", is the daily operation of the township government. The pressure is great and the task is heavy, which is a true portrayal of the current grassroots burden. The heavy burden makes the grass-roots struggling to cope, promotes the formalism of the grass-roots, leads to low administrative efficiency and waste of resources, and undermines the credibility of the government.

In order to solve this bad phenomenon in the process of grassroots governance, the party and the government have been trying to find a way to reduce the burden of grassroots. Since the 20th National Congress of the Communist Party, the party central committee attaches great importance to, plans and deploys to promote the rectification of formalism to reduce the burden on the grassroots. In 2018, focusing on a large number of meetings and materials, the General Office of the Central Committee of the Communist Party of China issued a notice on coordinating and standardizing the work of supervision, inspection and assessment[1]. In 2019, the General Office of the Central Committee of the Communist Party of China issued the "Notice on Solving the Prominent Problems of Formalism to Reduce the Burden at the Grass-roots Level", and identified 2019 as the "Year of Reducing the Burden at the Grass-roots Level", which opened the prelude to reducing the burden for the grass-roots level[2]. In 2020, the General Office of the Central Committee of the Communist Party of China issued a notice on "continuously solving the problem of formalism that plagues the grass-roots level to provide a strong style guarantee for a decisive victory in building a well-off society in an all-round way", and put forward practical measures to solve formalism in the process of epidemic prevention and control[3]. In 2021, the General Office of the Central Committee of the Communist Party of China issued "the main measures and division of labor plan for further solving the problem of formalism to reduce the burden of grassroots work in 2021",summarizing the old problems and new manifestations, and proposing solutions one by one[4]. In 2022, the China Office and the State Office issued the "Opinions on Regulating the Work Affairs, Mechanism Brands and Certification Matters of Village-level Organizations", which further refined the burden reduction rules[5]. In 2023, at the meeting of the special working mechanism for rectifying formalism at the central level to reduce the burden on the grass-roots level in Beijing, it was emphasized that the rectification and abstinence of formalism and bureaucracy should be placed in a more prominent position, and the party's work style, political style and social atmosphere should be continuously promoted. Upward, consolidate and streamline the work results of document meetings, coordinate and standardize supervision, inspection and assessment, and ensure that there is no resurgence[6]. On July 15,2024, the Third Plenary Session of the 20th Central Committee of the Communist Party of China made a deployment for continuously deepening and expanding formalism to reduce the burden at the grass-roots level, and clearly proposed to

improve the long-term mechanism for reducing the burden at the grass-roots level[7]. In order to implement the spirit of the Third Plenary Session of the 20th Central Committee of the Communist Party of China and the important guiding spirit of rectification formalism for grassroots burden reduction, in August 2024, the General Office of the Communist Party of China Central Committee and the General Office of the State Council issued a number of provisions on rectification formalism for grassroots burden reduction, which provided important guidance for grassroots burden reduction[8]. The No.1 Central Document in 2025 requires continuous rectification of formalism to reduce the burden at the grassroots level[9]. On February 5,2025, the meeting of the special working mechanism of the central level to rectify formalism for reducing the burden at the grass-roots level emphasized that we should continue to deepen the rectification of formalism for reducing the burden at the grass-roots level, and promote the party organizations at all levels and the majority of party members and cadres to complete the goal and task of the 14th Five-Year Plan with good style and high quality[10]. Over the years, under the centralized and unified leadership of the Party Central Committee and the joint efforts of various departments in various regions, the burden at the grassroots level has been curbed to a certain extent, but there is still a gap between the overall goal of reducing the burden of government decrees. The current grass-roots burden reduction has not yet achieved sustainable, long-term and inclusive burden reduction, and the grass-roots burden reduction is still ongoing.

2 LITERATURE REVIEW

The research on “grass-roots burden reduction” started around the 1990s, and the research boom focused on the “grass-roots burden reduction year” in 2019.

Scholars have different emphases on the concept of negative “burden” at the grassroots level. Zhou Zhenchao (2021) divided the typical manifestations of grassroots burden into heavy burden[12], heavy pressure, heavy consideration and heavy worry. Zhang Jingfu (2023) defined a clear concept of grass-roots burden[13], and believed that grass-roots burden is a heavy experience of grass-roots government staff in the process of continuous interaction with people inside and outside the government in order to implement policies. Some scholars use a more comprehensive perspective to explain the grassroots burden. Yong Liu (2024) believes that the burden is the product of the combination of subjective and objective[14]. Under the same task load, there are differences in the burden cognition and coping of grassroots cadres. Zhu Guanglei and Huang Yazhuo (2024) pointed out that “excessive burden”[15], that is, unnecessary and unbearable burden, actually refers to those responsibilities that exceed the normal power of the performing subject, including both positive responsibility(responsibility) and negative responsibility (accountability).

In terms of the source of grassroots burden, the academic community has conducted research from multiple perspectives. The pressure-based system proposed by Professor Rong Jingben is the most representative and has always been the main explanatory theory of grassroots pressure sources[16]. However, the existing research has found that the pressure-based institutional theory has some limitations in exploring the root causes of grassroots burden. As a result, scholar Hu Xiaodong(2022) used the “grounded theory” for qualitative research[17], and found that the reasons for the grass-roots burden were far beyond the explanatory framework of the pressure-type system theory. The burden at the grass-roots level is affected by multiple variables such as superior power, subordinate power, responsibility norms and supervision mechanism in the organizational system mechanism. It is necessary to adopt multiple governance measures to reduce the burden at the grass-roots level. In addition, the performance evaluation has spawned red tape burdens[18], the pressure and burdens on grass-roots governments and staff caused by conflicts between bars and blocks the pressures and burdens on grassroots governments and their staff stem from conflicts between vertical (top-down) and horizontal (cross-departmental) governance relationships.[12], the “isomorphism of responsibilities” among governments[15], and the formalism at the fingertips brought about by the excessive digital transformation of public organizations[19], which have explained the root causes of grass-roots burdens at different levels. Some scholars also believe that the increase of grassroots burden is related to the transformation of governance. Some scholars have noted that the re-concentration of top-down control rights is closely related to the weakness of grassroots governance[20]; in addition, with the refinement process of grassroots governance and the development of supervision to the countryside, the pressure of “ compliance” "of grassroots governance is increasing[21], and trace management is alienated[22]. Ye Min (2025) pointed out that the burden at the grassroots level is due to the comprehensive generation of a unified constructive state, social disability, and information technology environment[23].

On the object and goal of “reduction”, domestic scholars focus on empirical analysis to study the object and goal of grass-roots burden reduction. Mai Peiqing (2020) pointed out that the specific objects of grassroots burden reduction include complex account cleaning and data filling[24], excessive meetings and evaluation work, small power and heavy responsibility, many superior and temporary affairs, and difficulties in community multi-governance. In the elimination of formalism to achieve grass-roots burden reduction, on the one hand, we can start with meetings, reduce the interference of grass-roots civil servants’ work and innovation by reducing the number, compressing the duration, controlling the scale, innovating the form, and establishing the advance notice system, and at the same time improve the relevance and efficiency of meetings and work, so that meetings can return to the essence of “discussion”. On the other hand, it is necessary to scientifically allocate power according to the principle of legal rights and responsibilities, so as to avoid the situation that formalism is difficult to find. Cao Zhili (2023) proposed the optimization path of “de-licensing” “Logo-Cleanup” to promote the reduction of burdens[25]. He believes that this is an adjustment of grassroots power operation from the perspective of organizational symbols. “De-licensing” “Logo-Cleanup” is not the abolition of the functional institutions of the higher authorities in the community, but the local adjustment of the power

operation relationship between the higher government departments and the lower communities in grassroots governance, including the suppression of code-adding actions, the reshaping of hierarchical relations and the return of meaning value. Zhang Guolei and Gong Rui (2024) proposed to optimize the organizational structure of the "block" department in the bureaucratic system[26], so that the burden reduction policy can be quickly conveyed to the grassroots level. Give grassroots discretion and enhance work autonomy. Xiao Jinming and Jiang Baoqing (2024) established a new perspective of "adaptation-docking" grass-roots burden reduction bottom-up optimization path[27]. When faced with unconventional tasks, grass-roots governments "dock" task requirements by "adapting" the existing work content or planned resource elements on the spindle. Gui Hua (2025) believes that the burden reduction at the grass-roots level should have a clear goal[28], adopt high-level promotion and grass-roots promotion, adopt "small incision" and catch negative typical methods, and implement the work requirements from the masses to the masses.

Burden reduction at the grass-roots level is a governance practice with Chinese characteristics that has occurred in China's grass-roots society under the specific historical and realistic background. The implementation of burden reduction at the grass-roots level has lasted for several years. The perspective describes the basic fact that the grass-roots government has "heavy burden", analyzes the specific sources of the burden of the grass-roots government, and also interprets the internal logic of the burden dilemma at the grass-roots level from different perspectives. The existing research strongly proves the importance of studying the burden of grassroots government, and also provides a useful reference for our further analysis. However, there are still many spaces to be discussed in the study of grassroots burden. First, although the related research on grassroots burden is gradually increasing, these studies are scattered in sociology, politics, psychology and economics, and only focus on a specific manifestation of burden, and have not formed a systematic theoretical research, nor have they discussed its rich theoretical and practical connotations. Second, the existing research mostly adopts a top-down research perspective, such as the pressure-type system, and less analyzes the impact of the social environment actually faced by the township grassroots on its burden, and does not clarify the specific process of burden generation. Therefore, from the perspective of field theory, this paper puts the research of grassroots burden into the field of the new round of township institutional reform in the near future, in order to study the realistic situation of grassroots burden with systematic theories and cases, deeply analyze the realistic pattern and root cause of grassroots burden in the reform field, alleviate the "pain" brought by institutional reform, provide the way to eliminate grassroots burden, consolidate the reform results and improve administrative efficiency.

3 THEORY ANALYSIS FRAMEWORK

Field theory holds that "field" is composed of various objective historical relations attached to various positions of a certain power or capital form. Each field stipulates its own unique values and has its own unique control principles. These principles define a space for social construction, and actors operate according to their position in space in order to change or maintain their position. The concept of "capital" is different from the concept of capital used by economists. He regards capital as accumulated labor (including economic capital, cultural capital, social capital and symbolic capital, etc.), which can be occupied by actors or groups as social resources on an exclusive basis. "Habitus" is a persistent, transferable system of temperament, including personal knowledge and understanding of the world, which creates a "separation" from the real world[29]. "Field" "capital" and "habitus" are a set of dynamic and mutually constructed relationships. The field determines the distribution of capital and the shaping of habitus. The competition of capital reshapes the field pattern, and habitus will have a certain impact on the field[30]. This paper takes the new round of township institutional reform as the research field, constructs the analysis framework of "field-capital-habitus", and makes provides a comprehensive analysis of the grass-roots burden.

4 THE CONTENT OF TOWNSHIP INSTITUTIONAL REFORM IN L TOWN

4.1 Basic Situation of L Town

L town is under the jurisdiction of C city in Yunnan Province. It is located in the north of C city. It has an area of 193.4 km2 and a population of about approximately 28,000. L town has comprises 9 villager committees and 148 villager groups. L town was the main post station in western Yunnan in ancient times. There are several arterial highways and the 320 National Highway crossing the territory, with very convenient traffic. There are the two largest reservoirs in the autonomous prefecture, serving as the main sources of urban water supply in C city. The climate of L town is mild and humid. There is no severe cold in winter and no severe heat in summer. The soil in the town is mainly paddy soil and alluvial soil, followed by purple soil and red soil. The proven underground deposits in L town include coal, copper, sandstone, shale, clay, etc.

4.2 L Town Institutional Reform Content

In terms of institutional adjustment, L town has comprehensively established 8 working institutions, including the Party and Government Comprehensive Office, the Grassroots Party Building Office, the Economic Development Office, the Social Affairs Office(with the sign of Veterans Service Station), the Peace and Law Office, the Party and Masses Service Center(incorporating the sign of New Era Civilization Practice Station), the Comprehensive Administrative Law Enforcement Team(with the signs of full-time government fire brigade and fire station),and the Agricultural and Rural Development Service Center. To rationalize its working relationship with municipal departments, the town has

established a coordination mechanism and developed a “one-to-many” and “many-to-one” mechanism.

In terms of responsibility adjustments, the mandates of each agency are clearly defined. For example: The Party and Government Comprehensive Office manages daily operations, logistics support, and other administrative affairs of the organ; The Economic Development Office oversees economic development planning, industrial development, and project promotion; The Comprehensive Administrative Law Enforcement Team undertakes comprehensive administrative law enforcement and emergency rescue tasks. Additionally, the core responsibilities of the town Party committee and government are specified, including strengthening Party building, promoting economic development, enhancing public services, maintaining security and stability, and implementing comprehensive governance.

In terms of decentralization, "C" City has delegated a total of 112 project powers to "L" Town, including 2 administrative licensing items, 108 administrative penalty items, 1 administrative payment matter, and 1 other administrative power. Regarding service models and platform construction: The city provides business guidance and agency service support for enterprises and the public, establishes and improves the town-village government service system, ensures technical support for “Internet+government” “e-government services” services, promotes the application of the provincial government service platform, guides the construction of village-level convenient service stations, and relies on the Party-Mass Service Center to build an accessible service platform, thereby enhancing the convenience and efficiency of public services.

In terms of law enforcement authority and responsibilities, the comprehensive administrative law enforcement team exercises relevant administrative penalties, administrative enforcement measures, and supervision and inspection rights in accordance with the law, and is responsible for law enforcement in many fields within the jurisdiction, such as ecological environment, natural resources, agriculture and rural areas. At the same time, it should improve and implement the linkage mechanism of law enforcement cooperation, manage and coordinate the comprehensive administrative law enforcement command platform, and improve the synergy and effectiveness of law enforcement.

The overall staffing situation: The L town authorities approved 27 administrative staff, 11 leadership positions, 43 approved career positions, and 3 deputy section-level leadership positions. To implement the classification management of establishments, the town has optimized overall personnel allocation and adopted a post system for internal institutions. Responsibilities are assigned according to post requirements, and the principles of “one person taking multiple posts” and “one post shared by multiple people” have been implemented. This ensures a balanced match between staff strength and post tasks.

Personnel management and evaluation: The town strengthens supervision and evaluation of job performance, improves the job evaluation mechanism, and compacts job responsibilities, so as to enhance the efficiency and quality of personnel work. This ensures that employees are suited to their posts, make the best use of their abilities, and fulfill their duties effectively.

5 ANALYSIS OF THE GRASS-ROOTS BURDEN IN THE NEW ROUND OF TOWNSHIP INSTITUTIONAL REFORM IN L TOWN FROM THE PERSPECTIVE OF FIELD THEORY

5.1 Field Change: Structural Characteristics and Reform Tension of L Town Field

Bourdieu’s field theory holds that the field is a social space composed of specific rules, power relations, and competitive logic. In the context of township institutional reform, this field exhibits characteristics of complexity and dynamics. Through the institutional reform of L Town, its policy field has been reconstructed, and the organizational structure has been integrated and adjusted. Factors including vertical administrative pressure, horizontal departmental games interactions, and external social expectations have jointly shaped the operational field of township institutional reform.

In China’s administrative system, townships serve as the grassroots link between the state and society, undertaking the “last mile” responsibility for policy implementation. However, during township institutional reforms, superior municipal governments often impose pressure through indirect means like performance evaluations and power delegation, which (virtually) increases grassroots burdens. Higher-level governments typically use quantitative metrics—such as “online processing rates for government services” and “comprehensive law enforcement case completion rates”—to assess township performance, linking results to financial allocations and cadre promotions. For instance, L Town’s Comprehensive Administrative Law Enforcement Team must not only handle environmental protection, agriculture, and other enforcement tasks but also meet case completion rate targets; failure may result in criticism or funding cuts. This “digital management” model forces grassroots cadres to prioritize report-filing over actual problem-solving. Meanwhile, while reforms emphasize “decentralization, regulation, and service”—delegating approval and enforcement powers from cities to townships—corresponding staffing, funding, and technical support often do not follow. L Town’s Party-Mass Service Center, for example, manages multiple administrative approval tasks but lacks professional staff, leading to situations where duties are “unable to be accepted or poorly managed”. This mismatch of “responsibility (delegated downward) without resource allocation” traps townships in a dilemma of “unlimited responsibilities with limited capacity”.

Township institutional reform emphasizes “super-ministry integration”, with L Town consolidating originally decentralized functions into eight offices. However, this process has not eliminated interdepartmental interest games; instead, resource scarcity has intensified internal competition. Post-reform, the total number of administrative (27) and career staff (43) in the township is fixed, yet all offices—such as the Party and Government Office and Law

Enforcement Office—vie for more personnel to reduce workloads. The Economic Development Office, tasked with investment attraction and project promotion, may require additional staff, while the Peace and Rule of Law Office needs more hands due to stability maintenance pressures. This "zero-sum game" increases internal coordination costs. Although the reform aims to clarify institutional responsibilities, cross-cutting areas like environmental law enforcement—involving agriculture, natural resources, and other departments—still face buck-passing. For example, an enterprise's sewage discharge issue saw the law enforcement team claim it fell under the Environmental Protection Agency's jurisdiction, while the agency insisted on township-level territorial management, leading to prolonged delays. The reform mandates a "one-to-many coordination mechanism"—where a township agency interfaces with multiple superior departments or multiple agencies collaborate on tasks—but without mandatory mechanisms, interdepartmental information silos remain unbroken. The Party-Mass Service Center must connect with civil affairs, social security, and market supervision systems, but disjointed platforms force grassroots cadres to re-enter data, exacerbating administrative burdens.

One goal of township institutional reform is to enhance public service efficiency, yet the masses' increasingly diversified and refined needs contradict townships' limited service capabilities. While the reform promotes "Internet + government services", "e-government services", elderly and low-educated rural groups often face operational barriers. For example, L Town's online pension certification initiative leaves many seniors unable to use smartphones, forcing them to rely on village cadres for assistance and inadvertently increasing grassroots workloads. Every Sunday, villagers in L Town sell goods or homegrown agricultural products on designated streets, boosting household incomes, fostering regional exchanges, and elevating rural economic activity—but also creating significant traffic management challenges. Under this round of reform, the comprehensive administrative law enforcement team has gained administrative penalty powers. However, in township's typical "acquaintance society", strict enforcement may trigger public resistance. Fines for road-side vendors, for instance, are easily criticized as "inhumane". Law enforcement team members face a dilemma: the only street where stalls operate is aware of villagers' hardships in running small businesses, yet lax enforcement risks supervisory penalties. Law enforcement team members face a dilemma: they are aware of villagers' hardships in running small businesses on the only street where stalls operate, yet lax enforcement risks supervisory penalties.

Within the reform field of township institutions—a field shaped by the interplay of multiple forces—these factors collectively create a high-pressure, low-autonomy environment. Grassroots cadres are compelled to shoulder boundless responsibilities with limited resources, ultimately trapped in the pragmatic dilemma of overwhelming burdens.

5.2 Capital Imbalance: The Realistic Basis of Increasing Burden at the Grass-Roots Level

Under the framework of Bourdieu's field theory, capital is not only a resource for actors to compete, but also a key factor in shaping the power structure of the field. Although the institutional reform of L town has realized the integration of "super-ministry" in the organizational structure, it the reform presents an unbalanced state at the level of capital distribution, which directly leads to the aggravation of the burden at the grass-roots level.

5.2.1 Lack of economic capital and loss of administrative efficiency

In township governance, economic capital primarily reflects financial fund allocation and material resource distribution. During reform, L Town faces severe economic capital constraints. Despite having 27 administrative and 43 career staff approved, the gap between actual disposable funds and reform needs remains huge. Take the comprehensive administrative law enforcement team: responsible for ecological environment, natural resources, and agricultural law enforcement, the team theoretically requires equipment like law enforcement recorders, testing devices, and specialized vehicles. However, township finances struggle to cover these essential costs. Field surveys show the team currently has only two law enforcement recorders and lacks professional testing equipment, forcing reliance on non-standard methods like "visual inspection" and "empirical judgment".

Economic capital shortages also affect personnel welfare. L Town's average monthly staff salary is approximately 3,800 yuan, below the local institutional average. This low compensation creates two critical issues: first, difficulty attracting professionals, particularly in law and environmental protection; second, dampened morale among existing staff, leading some cadres to disengage or seek transfers out of grassroots via secondment. Without adequate economic capital, the reform's goals of "professional law enforcement" and "efficient service" remain hard to achieve.

5.2.2 Social capital reset and collaborative governance dilemma

Social capital refers to actors' relational networks and trust resources. L Town's reform has significantly impacted its original social capital networks. In vertical relations, the reform's "one-to-many" working mechanism aimed to streamline processes. However, urban-rural departmental information silos force townships to repeatedly interface with multiple superior agencies. For instance, when managing industrial support projects, the Agricultural and Rural Development Service Center must concurrently coordinate with the Agricultural Bureau, Finance Bureau, and Rural Revitalization Bureau. Disjointed departmental reporting systems require staff to re-enter similar data repeatedly.

In horizontal relations, institutional mergers have disrupted the original work tacit understanding. Prior to reform, station heads had formed a stable cooperation model; post-reform, newly established offices must rebuild trust. Investigations show the Peace and Rule of Law Office and Integrated Administrative Law Enforcement Team often shirk responsibilities during case transfers, primarily due to divergent interpretations of newly delineated responsibility boundaries. Additionally, social capital between village-level organizations and township governments is eroding. Rising assessment pressures have tightened township requirements for village cadres, but the absence of corresponding incentives has sparked resistance, leading to lukewarm policy implementation.

5.2.3 Mismatch of cultural capital and capacity crisis

Cultural capital manifests in cadres' knowledge structures, professional skills, and administrative literacy. A key issue in L Town's reform is the mismatch between the cadre team's cultural capital and reform requirements. Post-institutional merger, staff must assume broader responsibilities. For instance, Party-Mass Service Center personnel must not only be versed in traditional Party work but also master delegated administrative approval procedures and possess digital office capabilities. However, of the center's 12 staff, only 3 have received systematic professional training, with the rest "learning on the job".

The comprehensive administrative law enforcement team's case is more typical. The team handles law enforcement across multiple sectors—ecological environment, agriculture, and natural resources. Yet of its 15 members, only 2 have legal professional backgrounds; the rest were transferred from other posts. In an aquaculture pollution case, team members' unfamiliarity with environmental regulations led to flawed enforcement procedures and subsequent administrative disputes.

Cultural capital shortages not only undermine work quality but also heighten cadre anxiety. Multiple interviewed cadres reported feeling incompetent when faced with ever-updating policy requirements and professional technical knowledge.

5.2.4 Symbolic capital competition and formalism breeding

Symbolic capital encompasses intangible assets like reputation and prestige. In L Town's reform, the overemphasis on symbolic capital has become a key driver of grassroots burden. Superior governments allocate symbolic capital through "evaluation prioritization" and "assessment rankings". To gain recognition, townships invest substantial resources in creating "highlight model projects". For instance, during the "Internet+ government service" "e-government services" evaluation, L Town heavily funded a high-standard township service center, but outdated village service point equipment and poor network connectivity undermined its actual effectiveness.

The pursuit of symbolic capital also distorts work priorities. Surveys show each office handles an average of 32 assessment indicators, with approximately 60% being process-oriented (e.g., ledger reviews, system entries). To excel in these "visual" evaluations, cadres spend substantial time crafting elaborate reports and organizing inspection materials, at the expense of problem-solving. A Party and Government Office staffer candidly noted: "Most time now goes to paperwork, leaving minimal room for actual task execution."

5.3 Habitual Solidification: The Action Logic of Burden Continuation

In L Town's institutional reform, the persistence of grassroots administrative burdens stems not only from explicit factors like system design and resource allocation but also from grassroots cadres' ingrained thinking and behavioral patterns. Bourdieu's concept of "habitus" offers a crucial lens for understanding this phenomenon. Field research in L Town reveals a profound tension between the newly established institutional structure and existing work habits, which not only undermines some reform outcomes but also reinforces original grassroots burdens to some extent.

5.3.1 Administrative inertia under path dependence

Although L Town's institutional reform has significantly restructured original station setups, grassroots cadres' work mindsets remain deeply rooted in traditional administrative inertia. This path dependence manifests in the following ways.

The "assessment-centered" work orientation remains deeply ingrained. Surveys show that even after establishing comprehensive Party and Government Offices, staff still dedicate over half their energy to handling superior assessments. A long-serving Party and Government Office cadre admitted: "Although the office name has changed, assessment methods remain unchanged—we still have to prioritize assessment indicators." This habit has caused institutional operations to continue the old "assessments dictate actions" model.

"Line thinking" remains entrenched. Despite the "super-ministry system" integration in institutional design, cadres still default to working along original departmental hierarchies in practice. Staff at the Agricultural and Rural Development Service Center, for example, still subconsciously identify as "agricultural technology station cadres", resisting cross-center tasks. This identity lag in identity recognition seriously undermines organizational synergy.

The passive execution work model remains fundamentally unchanged. While the reform aims to enhance township autonomy, the long-standing "wait-and-rely" mentality has left grassroots cadres lacking initiative and proactive capabilities. During interviews, multiple cadres stated: "We dare not innovate without explicit instructions from superiors." This passivity has caused many reform measures to remain at the policy document level, hindering genuine implementation.

5.3.2 The strengthening of risk aversion behavior

After the institutional reform, cadres in L Town exhibit not less but more risk aversion, driven by changes in the power-responsibility dynamics.

This manifests in two ways: First, selective law enforcement. Despite gaining broader enforcement powers, comprehensive administrative law enforcement team members often employ a "selective enforcement" strategy to avoid triggering petitions or accountability. As one team member admitted: "We only penalize acts clearly illegal and uncontroversial; other cases are deferred for mediation." This "less is more" mentality undermines law enforcement efficacy. Second, excessive caution in administrative approval. The Party-Mass Service Center has assumed multiple delegated approval authorities, yet staff generally adopt practices like "rejecting incomplete applications" and "escalating difficult issues" due to approval error fears. In emergency management, even for clearly authorized matters, grassroots cadres tend to seek superior instructions. The Ping An Rule of Law Office head stated: "With strict

accountability, we'd rather be slow than make mistakes." Such overcaution severely impacts handling efficiency.

The ingrained work habits of L Town's grassroots cadres are far from accidental; they are deeply rooted in the current institutional environment. First, the assessment-accountability system creates perverse incentives. Overemphasizing a "no accidents" logic, the system discourages innovation by treating any initiative as a potential risk. As a town leader candidly noted: "The more you do, the higher the error risk—better to play it safe." This institutional bias reinforces conservatism. Township cadres also face limited promotion prospects, with most stuck in career "ceilings". Such stagnation dampens motivation to adapt to reform and fosters a "status quo" mindset. Second, the lack of a structured training system compounds the issue. Post-reform, there is no systematic capability-upgrading mechanism, leaving cadres to navigate new workflows through trial and error. A new civil servant remarked: "No one taught me the ropes—just told to follow senior colleagues." This informal knowledge transfer perpetuates old habits.

5.3.3 The Conflict and Adjustment of the Old and New Habitus

During the reform, L Town's cadres are caught in a transition between old and new work habits, triggering multiple adaptability issues—such as role conflicts from "one person, multiple posts". The reform's demand for "versatility" clashes with cadres' long-standing professional specialization habits. As an Agricultural and Rural Development Service Center cadre noted: "Yesterday I was promoting agricultural technology; today I'm handling water disputes. I know a little of everything but excel at nothing." This role confusion reduces work quality and fuels job burnout.

Additionally, digital office adaptation remains challenging. The "Internet + government services" initiative requires cadres to master new workflows, but some senior cadres struggle to adapt. Data from the Party and Mass Service Center shows that staff aged 45+ have a digital platform error rate over three times higher than their younger colleagues. This lag in technological habit adaptation has undermined overall service efficiency.

6 FIELD FACTOR ADJUSTMENT : THE ELIMINATION PATH OF GRASS-ROOTS BURDEN

6.1 Reconstruction of Field Rules : Breaking Structural Oppression

6.1.1 Rebalance of power and responsibility relationship : to build a scientific and reasonable division of responsibilities system

Establish a "negative list" system. The current overextension of "territorial management" in grassroots governance essentially involves higher-level governments shifting responsibilities to townships through administrative mandates. Take L Town: in environmental law enforcement, the township lacks professional testing equipment and law enforcement personnel, rendering it practically incapable of fulfilling related duties, yet it is still required to assume territorial management responsibilities. This phenomenon flagrantly violates the administrative principle of "power-responsibility equivalence".

To address this, a scientific "negative list" system should be established. First, led by municipal people's congresses or government legal departments, systematically compile township governments' statutory duty lists in accordance with laws such as the Organic Law of Local People's Congresses and Local People's Governments at All Levels. Second, highly specialized tasks requiring specific qualifications or equipment (e.g., environmental monitoring, food safety inspections) should be explicitly categorized as "negative list" items with "territorial management exemptions". Finally, implement a strict "duty access" mechanism: for tasks requiring township assistance, municipal departments must issue written authorization documents and provide synchronized support in professional personnel, funds, and equipment.

6.1.2 Dynamic programming adjustment mechanism

The "super-ministry" integration in township institutional reform often remains a mere "physical merger" without achieving a "chemical reaction". After L Town consolidated its original 15 stations into 8 offices, reduced institutional numbers were offset by increased workloads from delegated powers, straining resources. To resolve this dilemma, a resource-power dynamic matching mechanism is needed, with specific measures as follows: First, establish "authority-workload accounting standards". For example, if L Town's comprehensive administrative law enforcement team handles 200 cases annually, requiring 2 person-days per case (400 person-days total), staffing should be allocated based on approved workloads. Second, implement an "establishment turnover pool" system: the municipality should reserve 5%–10% of professional staffing as mobile quotas for dynamic allocation according to townships' delegated powers. Third, innovate a mixed "establishment + purchased services" model, allowing townships to procure social services for seasonal/temporary tasks (e.g., flood control and drought relief).

6.1.3 De-formalization of the assessment system : building an effectiveness-oriented evaluation mechanism

Implement "results-oriented" assessment reform. Grassroots assessment dilemmas stem from overemphasizing process management while neglecting actual outcomes. Surveys show L Town cadres handle an average of 32 assessment indicators, 19 of which involve process requirements like ledger reviews and system entries—seriously compromising public service time. To address this, rebuild the assessment index system. First, drastically reduce process indicators, cutting their original 60% assessment weight to below 20%. Second, establish an effectiveness evaluation system centered on "problem resolution rates" (e.g., petition case completion rates) and "public satisfaction" (random sampling survey results). Finally, introduce a "cross-validation" mechanism to curb data fraud—for example, having assessment teams randomly select 10% of resolved livelihood issues for on-site reviews or telephone follow-ups. Take L Town's Party and Mass Service Center: replacing process indicators like "work guideline update frequency" with outcome metrics like "public trip reduction rate" truly reflects the "streamline administration, delegate powers, and improve regulation and services" reform efficacy. This shift in assessment methods guides grassroots cadres to redirect efforts

from “paper trails” to “tangible results”.

Implementing differentiated assessment design is essential given the significant regional disparities among China’s townships, where current assessment systems often apply “one-size-fits-all” standards that overlook local peculiarities. Take L Town’s weekly “street market”, a tradition that preserves traditional market culture and serves as a vital income source for villagers, yet faces enforcement dilemmas due to rigid “no road occupation” assessment indicators. To address such conflicts, a differentiated assessment system must prioritize contextual adaptability: replacing simplistic “prohibition” mandates with metrics like “mobile vendor standardization rates” to focus on whether special operation zones are demarcated and health management protocols are enforced; allowing townships to adjust up to 20% of assessment criteria based on local realities to ensure rules align with on-the-ground needs; and establishing a fault-tolerant mechanism to mitigate deviations in indicator completion caused by regional particularities through systematic evaluation. For instance, designating L Town’s “street market” area as a temporary operation demonstration zone with tailored assessment standards balances urban order and livelihood requirements, exemplifying how flexible assessment frameworks can respect the complexity of grassroots governance while fostering pragmatic solutions.

The “digital divide” confronting elderly populations has emerged as a critical challenge in digital government development, exemplified by L Town’s experience with online pension certification, where approximately 35% of seniors relied on village cadres for in-person agency assistance due to smartphone inexperience, thereby exacerbating grassroots administrative burdens. Addressing this requires a holistic “online+offline” parallel service model that integrates technological accessibility with human-centered support: developing age-friendly digital interfaces featuring large fonts, simplified workflows, and voice guidance to lower online usage barriers; maintaining physical service windows in each administrative village staffed with "digital assistants" to provide hands-on support; and equipping villages with portable authentication terminals to enable on-site service delivery. In L Town, such a model could manifest through a “Silver Age Window” at the convenience service center, where full-time staff assist seniors with certification processes, while village cadres trained in “family proxy” functions use specialized equipment to offer home-based services for mobility-impaired elders. This approach not only aligns with the trajectory of informatization but also upholds the rights of vulnerable groups, transforming digital governance from a potential source of exclusion into a tool for empowerment—ensuring that technological advancement serves as a bridge rather than a barrier in grassroots governance.

6.2 Redistribution of Capital: Reconstructing the Basis of Competition

6.2.1 Economic capital supplement: building a sustainable financial security mechanism

A core contradiction in current township institutional reforms lies in the asynchronous synchronization of decentralized powers and financial security. A core contradiction in current township institutional reforms lies in the lack of synchronization between decentralized powers and financial security. For instance, L Town’s comprehensive administrative law enforcement team handles 200 cases annually with a mere 50,000 yuan annual budget, which scarcely covers essentials like law enforcement recorder updates and detection equipment maintenance. Resolving this requires a scientific fiscal power matching mechanism integrating three key components: first, a standardized “workload × unit cost coefficient” accounting method, where county-level finance departments, in collaboration with functional agencies, classify and approve unit costs for different administrative tasks (e.g., 300 yuan per summary procedure case, 800 yuan per general procedure case, and 50 yuan per administrative approval item); second, a “fee-for-service” transfer payment system that dynamically adjusts funding based on actual township workloads (e.g., L Town would receive 102,000 yuan annually for its 200 cases, factoring in 30% general procedures); and third, a “project funding contract system” granting townships greater autonomy to reallocate funds across projects while maintaining total budgetary ceilings. This refined, dynamic financial security model effectively addresses the institutional paradox of "assigning tasks without allocating resources."

To expand funding sources, innovate a “capital transformation” incentive mechanism. L Town, despite its abundant resources, has annually raised approximately 500,000 yuan through rural sage associations in recent years, yet financial management constraints hinder converting these donations into public service investments. A “social donation matching reward” policy is proposed: for every 1 yuan of social capital raised by the township, county-level finance would provide a 0.5 yuan matching grant, allowing the total to count toward the project’s self-financed portion.

6.2.2 Cultural capital upgrading : to build a compound cadre team

Township institutional reforms demand higher competency standards for cadres. A survey reveals that staff at L Town’s Party and Mass Service Center must master over 120 administrative approval standards, yet existing training remains fragmented and perfunctory, failing to address practical needs. To tackle this, implement a systematic capability enhancement program: roll out a “1+X” competency certification plan, requiring each cadre to master at least two cross-domain skills (e.g., basic legal knowledge and e-government operations) alongside their core expertise (e.g., social assistance policy for civil affairs cadres). County-level human resources departments should administer certification exams, with passers receiving a monthly 300-yuan allowance and promotion-related bonuses. For instance, L Town’s comprehensive law enforcement team members could be mandated to pass law enforcement qualification exams and master environmental and agricultural regulations within three years, shifting from “single-issue enforcement” to “comprehensive enforcement” capabilities.

To bridge the gap in law enforcement capabilities, a practical - oriented training system is imperative. Jointly establish an "Administrative Law Enforcement Training Base “with local courts and conduct” case workshop training. Select 20

typical law enforcement cases from L Town over the past three years, including road-occupying operations and aquaculture pollution disputes. A tutor team, composed of judges, lawyers, and industry experts, will guide trainees through full-process simulations, from case investigation to legal document drafting. The training features a credit system of "40 compulsory hours + 20 elective hours". Trainees who do not meet the requirements will have their law enforcement qualifications temporarily revoked. Moreover, the "tutor – stationed" system will be implemented. Each month, judges from the court's administrative tribunal will provide on-site case guidance in L Town, helping cadres enhance their legal acumen in real-world scenarios. This "theory - practice integrated" training model effectively remedies the lack of confidence in grassroots law enforcement.

6.2.3 Activation of social capital : building a multi-collaborative governance network

Traditional management mindsets that treat mobile vendors merely as rectification targets exacerbate governance conflicts. L Town can innovate by implementing a "Governance Partner" plan: democratically elect 5–7 "street chiefs" from merchants, empowering them with stall allocation and minor violation handling authority. A "credit scoring" system should be established to grant lease renewal priorities, tax breaks, and exemptions to vendors who comply with business orders and participate in environmental maintenance. Additionally, a monthly negotiation mechanism involving law enforcement teams, business representatives, and community residents can resolve operational order issues through collaborative governance.

To address data sharing challenges, dismantling "information silos" is urgent. The municipal government should spearhead the construction of a "government data platform", mandating all departments to open data interfaces. By integrating high-frequency data from civil affairs, social security, and market supervision, L Town's Party and Mass Service Center can achieve "one-time input, multi-system auto-population". Next, developing an "intelligent pre-screening" function will enable the system to automatically cross-check departmental databases and flag missing information when the public submits materials. In the third phase, establishing an "electronic certificate repository" will auto-collect certification documents from various departments, eliminating redundant requests.

6.3 Reshaping Habitus : Cultivating New Practical Logic

6.3.1 Breaking the path dependence : building an institutional environment to encourage innovation

The pervasive accountability avoidance in grassroots governance stems from asymmetric accountability mechanisms. L Town's empirical data shows 82% of cadres adopt "risk-averse decision-making", severely hampering reform efforts. A systematic fault-tolerant mechanism is crucial to address this. Led by the County-level Commission for Discipline Inspection, a rights-responsibility list system should be established. This includes a "Reform and Innovation Fault-Tolerance List" with 12 exemption categories, clarifying boundaries for lenient handling of first-time minor violations and reasonable emergency misjudgments. A case guidance system, releasing 3-5 quarterly exemplary fault-tolerant cases (e.g., effective but procedurally flawed epidemic controls), can set precedents. Additionally, an "error correction-accountability" mechanism should allow non-subjective negligence to be rectified instead of punished.

In L Town's law enforcement, first-time road-occupation violations receive warnings, and repeated offenses do not retroactively penalize initial enforcers. This approach eliminates "dishwashing effect" concerns, enabling bolder governance. By defining exemptions, leveraging case guidance, and refining accountability, the mechanism resolves the "less action, fewer errors" dilemma.

Reconstructing power-responsibility dynamics, the "reverse assessment" mechanism offers significant institutional innovation potential. A two-way county-township evaluation system is proposed: townships should conduct semi-annual quantitative assessments of county-level departments' "resource support", focusing on 10 key indicators, including staffing allocation and authority delegation. These evaluations, accounting for 15% of departmental performance scores, would incentivize responsiveness. In L Town, the system could prioritize assessing support for administrative approvals; departments failing to deliver on promises regarding personnel and equipment decentralization would trigger corrective actions.

6.3.2 Reconstructing identity: cultivating the subject consciousness of modern governance

After the reform of township institutions, cadres' role cognition often lags significantly behind organizational changes. In L Town, after the agricultural technology and water conservancy stations merged into the Agricultural and Rural Service Center, some original staff still identified as agricultural technicians and declined to handle water - related tasks. To address this, an in - depth identity reconstruction project is needed. A general cadre qualification certification system should be established, consisting of three assessment modules: basic knowledge (40%), practical skills (40%), and public evaluation (20%). Cadres must complete cross-departmental rotation, like a three-month exchange between the Party - government office and law enforcement team, to obtain certification. Linking certification results directly to rank promotion encourages cadres to adopt the new identity of "township cadre" over "station-specific cadre".

Deeper identity reconstruction necessitates cultural innovation. L Town could implement a "governance narrative" remodeling project by organizing cadres and villagers to co-compile a rural community development history, documenting collaborative stories from key initiatives like poverty alleviation and environmental remediation through oral histories. During compilation, cadre household interviews would collect authentic cases—such as "cadres repairing my water pipes" and "joint river cleanups"—for dissemination via WeChat official accounts. This participatory storytelling enables grassroots cadres to emotionally transition from "managers" to "servers" through shared resonance.

6.3.3 Transformation of technical habitus : building a new model of smart work

Digital transformation presents significant challenges for aging cadres, as evidenced by L Town's case where 62% of

cadres are over 45 and 43% experience “digital anxiety”. Addressing this requires a holistic digital adaptation strategy. A simplified OA system could streamline document approval into three core steps—“receive-process-submit”—while graphical operation guides with red arrows highlighting key steps and magnifying-glass visual aids would enhance usability. Establishing “digital counselor” roles for young cadres or volunteers to provide one-on-one support further bridges the gap. Equally critical is a staggered-peak training system that avoids busy farming periods, adopting a “1 hour daily” micro-training model to ensure consistent, low-pressure skill development. This integrated approach, combining technological simplification, visual guidance, personalized assistance, and flexible training, aims to alleviate digital anxiety and empower older cadres in the digital governance landscape.

7 CONCLUSION AND FORESIGHT

Drawing on Bourdieu’s field theory, this study systematically analyzes institutional reforms in L Town to reveal deep-seated contradictions in grassroots governance modernization. While L Town’s reforms have achieved “physical integration” of organizational structures, three operational challenges persist: field-level power-responsibility imbalances, structural gaps in capital allocation, and administrative habitus path dependence. By constructing a three-dimensional “field-capital-habitus” analytical framework, the study offers a systematic lens for understanding grassroots governance burdens.

In the future, the reform of township institutions must be deepened across three key dimensions. First, to promote the legalization of "rights, responsibilities, and interests" allocation, it is advisable to formulate a "township government responsibility list" and establish a dynamic adjustment mechanism for powers and expenditure responsibilities. Second, innovative approaches to capital accumulation should be explored, such as the "village sage fund + financial support" financing model, along with the development of a "digital twin" training system to enhance cadre capabilities. Third, the institutionalization of habitus transformation should be advanced by incorporating a "fault-tolerant mechanism" into local legislation and developing a "mental model" assessment tool for grassroots governance.

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Against the backdrop of the digital economy, the ability to balance technological empowerment with humanistic care, particularly in maintaining services for the elderly, will be a crucial criterion for evaluating reform effectiveness. Additionally, as the rural revitalization strategy progresses, the evolving interaction models between township governments, market entities, and social organizations merit continuous attention. Ultimately, the dual objectives of reducing grassroots burdens and enhancing governance efficiency can only be achieved by coordinating the reconstruction of field rules, optimizing capital allocation, and facilitating the benign transformation of administrative habits[31-33].

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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TEAM SIZE AS A MODERATING FACTOR IN REMOTE PROJECT MANAGEMENT: EVIDENCE FROM SAUDI ARABIA

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Abstract: This study investigates the moderating effect of team size on remote project management outcomes in Saudi Arabian organizations, addressing a critical gap in understanding optimal virtual team configurations in emerging markets. Through quantitative analysis of data collected from 289 project professionals across multiple sectors in Saudi Arabia, the research examines how varying team sizes influence project completion rates, resource utilization, and coordination efficiency in remote work environments. Using structural equation modeling and hierarchical regression analysis, the findings reveal that medium-sized teams (8-12 members) demonstrate optimal performance metrics in remote settings. In comparison, larger teams (>15 members) show diminishing returns in coordination efficiency and project completion rates. The study also identifies critical thresholds where increasing team size begins to negatively impact virtual collaboration effectiveness. Results indicate that team size explains 34% of the variance in project completion rates when controlling for project complexity and industry type. These findings contribute to project management theory by establishing team size as a significant moderating variable in remote project success, particularly within the Saudi Arabian context. The research provides practical implications for project managers in optimizing team configurations for remote work, offering evidence-based recommendations for team sizing based on project scope and complexity. This study advances our understanding of virtual team dynamics in emerging markets and provides a foundation for future research on team size optimization in remote project management.
Keywords: Team size; Remote project management; Virtual teams; Saudi Arabia; Project performance; Coordination efficiency; Team configuration; Project success factors

1 INTRODUCTION

The rapid transformation of labor environments, multiplied employing international technological development and recent pandemic-driven modifications, has made remote mission management an essential attention for companies international [1]. In Saudi Arabia, this shift has unique importance as businesses align with Vision 2030's virtual transformation desires while navigating the complexities of digital team management [2]. While full-size research has tested various factors of faraway project management, the particular effect of team size as a moderating aspect remains understudied, mainly within the Saudi Arabian context.

However, its position will become increasingly complicated in remote settings, wherein digital collaboration gear and geographical dispersion introduce new dynamics to group interactions. This complexity is in particular obtrusive in Saudi Arabia's business surroundings, wherein groups should balance technological adoption with conventional management practices [3].

Previous research has primarily focused on general aspects of remote team effectiveness [4] or cultural dimensions of virtual collaboration [5], Leaving a giant gap in expertise on how team size moderates challenge outcomes in remote settings. This gap is particularly said in rising markets like Saudi Arabia, in which rapid virtual transformation intersects with precise organizational cultures and control practices [6].

The present examination addresses this study's gap by analyzing how crew size moderates the connection between remote work arrangements and project effects in Saudi Arabian groups. Specifically, this study investigates 3 key factors: (1) the relationship between group size and venture crowning glory quotes in faraway settings, (2) the premiere crew length tiers for exclusive kinds of remote tasks, and (three) the moderating effect of crew size on coordination efficiency and aid utilization in virtual environments.

This look's importance lies in its capacity to tell proof-based choices approximately team configuration in remote mission management, especially within the Saudi Arabian context. The findings contribute to each theoretical knowledge and practical application, supplying insights that can assist companies optimize their remote group systems for more advantageous task fulfillment.

Drawing on records from 289 assignment professionals across various sectors in Saudi Arabia, this study employs a quantitative method to investigate the moderating outcomes of team size on remote mission effects. The examine makes use of structural equation modeling and hierarchical regression evaluation to have a look at these relationships, providing robust empirical proof for its findings.

2 LITERATURE REVIEW

The literature on crew size and its effect on project control spans numerous theoretical frameworks and empirical studies. This evaluation synthesizes existing studies across 3 key regions: theoretical foundations of group length effects, remote group dynamics, and empirical evidence from the Saudi Arabian context.

2.1 Theoretical Foundations of Team Size Impacts

The traditional organizational concept indicates that crew size significantly impacts group dynamics and performance consequences. [7] organizational conduct studies show that growing group size introduces exponential complexity in verbal exchange patterns and coordination necessities. This complexity is specifically applicable in venture control contexts, in which task interdependence and coordination desires are normally excessive [8].
The idea of social loafing, first identified by way of [9], turns into an increasing number of applications as crew length grows. Their studies demonstrate that man or woman contribution and responsibility tend to lower as crew length increases, a phenomenon that may be amplified in faraway settings in which direct supervision is constrained. This theoretical framework gives a basis for know-how of the potential drawbacks of large crew sizes in digital environments.

2.2 Remote Team Dynamics and Size Considerations

Recent research has begun to discover how conventional team-length theories are practiced in far-off settings. [10] complete evaluation of virtual group literature shows that the relationship between group size and overall performance may additionally observe exclusive styles in faraway environments compared to traditional settings. Their findings imply that verbal exchange demanding situations and coordination prices increase more hastily in digital groups as length increases.
Empirical research by [11] found that remote groups face particularly demanding situations related to length that are not found in co-positioned teams. A look at one hundred fifty virtual groups revealed that coordination efficiency was reduced by 15% for each additional group member past eight humans, suggesting a doubtlessly lower top-of-the-line length threshold for faraway groups as compared to conventional ones.

2.3 Team Size in Saudi Arabian Project Management Context

Within the Saudi Arabian context, several studies have examined project management practices, even though few have in particular focused on team size as a moderating issue. [12] research on Saudi corporations found that cultural factors affect most desirable group length configurations, with hierarchical organizational systems frequently favoring large teams despite capability efficiency losses.
[13] carried out one of the few research explicitly inspecting group length in Saudi faraway initiatives, finding that medium-sized teams (8 -12 participants) verified the most useful overall performance metrics in virtual settings. However, their studies became restricted to the era sector, leaving gaps in information across other industries.

2.4 Optimal Team Size Ranges and Performance Metrics

Recent meta-analyses have tried to establish premier crew size degrees for remote tasks. [14] analysis of 200 digital teams across a couple of industries recommended that performance begins to decline whilst faraway teams exceed 12-15 members, even though this varies by way of project kind and complexity. Their findings imply that smaller teams (5-8 contributors) often reveal better stages of engagement and coordination performance in digital settings.

2.5 Technological Mediation and Team Size

The role of generation in mediating crew size consequences has emerged as a crucial attention. Research using [15] suggests that superior collaboration tools can help mitigate a few demanding situations of large team sizes, even though they can't cast off the coordination charges associated with accelerated group clubs. Their look showed that even with the most beneficial technological support, remote groups larger than 15 contributors confirmed enormous decreases in decision-making performance and challenge of completion charges.

3 METHODOLOGY

3.1 Research Design

This takes a look at employs a quantitative studies layout to look at the moderating impact of group size on remote undertaking management effects in Saudi Arabian companies. The research makes use of a cross-sectional survey approach, allowing for the collection of facts from more than one corporation concurrently [16]. This layout enables the examination of relationships among group length, venture consequences, and various overall performance metrics at the same time as controlling for potential confounding variables.

3.2 Sample and Data Collection

The look at populace comprises assignment professionals running in far-flung groups across various sectors in Saudi Arabia. Using stratified random sampling to ensure representation across one-of-a-kind industries and organizational sizes, records were accumulated from 289 participants [17]. The pattern length became determined using the subsequent formula:

$n = (Z^2 \times p \times (1-p))/E^2$

where Z = 1.96 (95% confidence level), p = 0.25, and E = 0.05

Participants were recruited through professional networks and industry associations, with inclusion criteria requiring:

- Minimum one year of remote project management experience
- Current involvement in remote project teams
- Employment in Saudi-based organizations

3.3 Data Collection Instrument

A structured questionnaire was developed based on validated scales from previous research. The instrument was organized into several sections:

3.3.1 Demographic information

Participant demographics were accrued through a questionnaire phase that accumulated critical background records. Age was classified into five organizations: 18-25, 26-35, 36-45, 46-55, and over 56 years. Gender was recorded as male or woman. Education degrees became categorized into 5 classes: less than excessive school diplomas, high faculty degree or equal, a few colleges (no diploma), bachelor's diploma or better, and advanced ranges. Years of revel in far-off-venture management changed into captured across 5 stages: much less than 1 year, 1-3 years, 4-6 years, 7-10 years, and more than 10 years. Industry sectors had been labeled in accordance to standard classes inclusive of generation, finance, healthcare, training, production, and others. Current roles were recorded based totally on a predefined listing of task management positions consisting of challenge supervisor, group leader, coordinator, and team member.

3.3.2 Team size measures

Team-length information was accumulated via numerous targeted questions examining cutting-edge and beyond stories with faraway groups. Current crew size became recorded as the precise range of team members inside the participant's gift faraway assignment group. Previous enjoyment with special crew sizes changed into documented through having members suggest the numerous team sizes that they had labored with in remote settings, classified as small (≤7 individuals), medium (8-14 contributors), and big (≥15 individuals). Preferred team size for remote initiatives became captured by asking contributors to indicate their finest crew length variety primarily based on their experience, as well as the usage of the small/medium/large categorization. This phase supplied vital statistics for expert members' publicity and possibilities concerning group size in faraway challenge settings.

4 PROJECT PERFORMANCE METRICS

Performance metrics were measured using proven scales adapted from preceding studies. Project entirety prices have been assessed through questions on meeting cut-off dates, reaching milestones, and general project fulfillment quotes. Resource utilization performance becomes measured by the usage of metrics associated with budget adherence, aid allocation effectiveness, and premier use of team member abilities and time. Coordination effectiveness was evaluated through questions about team collaboration, undertaking distribution, and workflow management. Communication fine was assessed via measures of facts waft, readability of verbal exchange, and effectiveness of virtual communication equipment. Each metric was rated on a 5-factor Likert scale, with better rankings indicating higher performance.

The questionnaire utilized a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) for maximum objects, constant with previous studies in the area [17] [18].

4.1 Variables and Measures

4.1.1 Independent variable

- Team Size: Categorized as small (≤7 members), medium (8-14 members), and large (≥15 members)

4.1.2 Dependent variables

- Project Completion Rate (PCR): Measured using a validated 5-item scale
- Resource Utilization Efficiency (RUE): Assessed through a 4-item scale
- Coordination Effectiveness (CE): Evaluated using a 6-item scale

4.1.3 Control variables

- Project complexity
- Industry type
- Organization size
- Technology infrastructure

4.2 Data Analysis

4.2.1 Preliminary analysis

The preliminary segment of information analysis targeted on making sure facts nice and appropriate for statistical trying out. Data cleaning and screening involved checking for mistakes in data access and formatting inconsistencies. Missing value evaluation turned into conducted using Little's MCAR take a look at to decide if records have been lacking absolutely at random, with instances having more than 5% lacking values being excluded from the evaluation. Outlier detection employed univariate (z-ratings) and multivariate (Mahalanobis distance) strategies to pick out and compare severe cases. Normality testing protected analyzing skewness and kurtosis values, alongside visible inspection of Q-Q plots and histograms to ensure the statistics met assumptions for parametric checking out.

4.2.2 Reliability and validity assessment

The measurement model's reliability and validity had been fastidiously evaluated using more than one method. Cronbach's alpha coefficients were calculated for each assembly to evaluate internal consistency, with values above zero.7 taken into consideration as suitable. Confirmatory Factor Analysis (CFA) was done to evaluate construct validity, examining thing loadings and version match indices (CFI, TLI, RMSEA, and SRMR). Average Variance Extracted (AVE) values were calculated to evaluate convergent validity, with values above 0.5 indicating adequate convergence. Additionally, discriminant validity turned into set up by comparing the square root of AVE values with inter-assemble correlations.

4.2.3 Hypothesis testing

The study's hypotheses were examined using a complete multi-step analytical approach. For H1 ("Team size notably impacts assignment of entirety time"), hierarchical a couple of regression analyses were carried out, controlling for demographic variables (age, enjoy, training) and organizational factors (industry kind, era infrastructure). The evaluation examined the direct dating between group length classes and undertaking crowning glory metrics, with standardized β coefficients indicating the electricity and route of relationships.

For H2 ("Team size moderates resource utilization efficiency"), Hayes' PROCESS macro (Model 1) was employed to analyze the interaction effects between team size and resource utilization patterns. This moderation analysis included:

- Testing for main effects of team size
- Examining interaction terms
- Conducting simple slopes analysis at different team size levels
- Generating interaction plots to visualize moderating effects

H3 ("Team size influences choice-making pace") was examined through hierarchical regression analysis, with choice-making velocity measured via tested scales. The evaluation controlled for ability confounding variables and examined both linear and non-linear relationships among group length and choice-making performance.

For H4 ("Project complexity moderates the relationship among team length and undertaking performance"), Structural Equation Modeling (SEM) was employed to test the complex moderation results. The SEM analysis covered:

- Measurement model validation
- Path analysis of direct effects
- Testing of moderation effects through multi-group analysis
- Assessment of model fit indices (CFI, TLI, RMSEA)

Results from all analyses were evaluated at a significance level of $p < .05$, with effect sizes reported using Cohen's f^2 for regression analyses and R^2 for overall model evaluation. Bootstrap procedures (5000 samples) were employed to generate confidence intervals for indirect effects and moderation analyses.

Statistical tools used included:

- SPSS 27.0 for hierarchical regression analysis
- PROCESS macro v4.0 for moderation testing
- AMOS 26.0 for SEM analysis

4.2.4 Statistical tools and software

All statistical analyses were finished with the usage of SPSS version 27.0 for descriptive information, reliability analysis, and regression modeling. AMOS 26.0 became utilized for CFA and SEM analyses, enabling the assessment of complex direction relationships and version in shape indices. The PROCESS macro turned into included within SPSS to conduct moderation analyses effectively.

4.2.5 Ethical considerations

The research strictly adhered to moral tips at some point of all levels of the study. Informed consent was obtained from all members previous to the information collection, virtually explaining the observation's cause, capacity dangers, and blessings. Participant confidentiality was maintained through nameless information series and steady data storage procedures. Participants were informed of their proper to withdraw from the look-at at any time without outcomes. All statistics were stored securely on encrypted servers with limited access. They take a look at receiving approval from the Institutional Review Board (IRB) earlier than graduation, ensuring compliance with ethical research requirements and shielding members' rights for the duration of the studies system.

4.3 Results

The analysis of data collected from 289 project professionals in Saudi Arabian organizations revealed several significant findings regarding the impact of team size on remote project management outcomes.

4.4 Demographic Profile

Table 1 presents the demographic characteristics of the study participants. The majority of respondents (42.3%) were between 26-35 years old, with 68.2% being male and 31.8% female. Most participants (73.4%) held a bachelor's degree or higher, and 45.2% had 4-6 years of experience in remote project management.

Table 1 Demographic Characteristics of Participants

Variable	Category	Frequency	Percentage
Age	18-25	35	12.1%
	26-35	122	42.3%
	36-45	89	30.8%
	46-55	31	10.7%
	>56	12	4.1%
Gender	Male	197	68.2%
	Female	92	31.8%
Education	Bachelor's or higher	212	73.4%
	Some college	45	15.6%
	High school	32	11.0%
Experience	<1 year	28	9.7%
	1-3 years	67	23.2%
	4-6 years	131	45.2%
	7-10 years	42	14.5%
	>10 years	21	7.4%

4.5 Team Size Analysis

The analysis of team size categories and their relationship with project outcomes revealed significant patterns. As shown in Figure 1, medium-sized teams (8-14 members) demonstrated the highest project completion rates (M = 4.2, SD = 0.6) compared to small teams (M = 3.7, SD = 0.8) and large teams (M = 3.4, SD = 0.7).

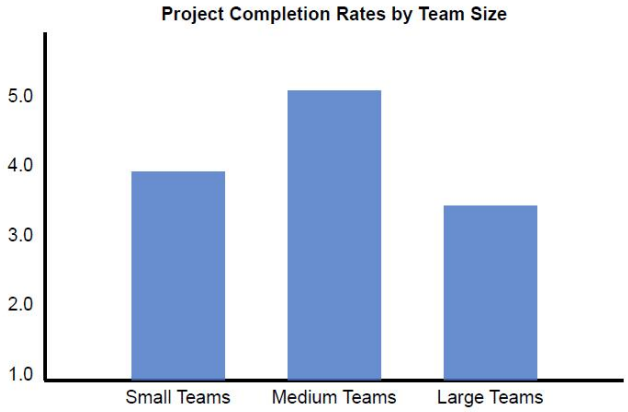

Figure 1 Project Completion Rates by Team Size

4.6 Hypothesis Testing Results

H1: Team size significantly affects project completion time
- Multiple regression analysis confirmed a significant relationship ($\beta = .45$, $p < .001$)
- Team size explained 34% of the variance in project completion time ($R^2 = .34$)

H2: Team size moderates resource utilization efficiency
- Moderation analysis revealed significant interaction effects ($\beta = .38$, $p < .001$)
- Stronger effect observed in medium-sized teams (see Figure 2)

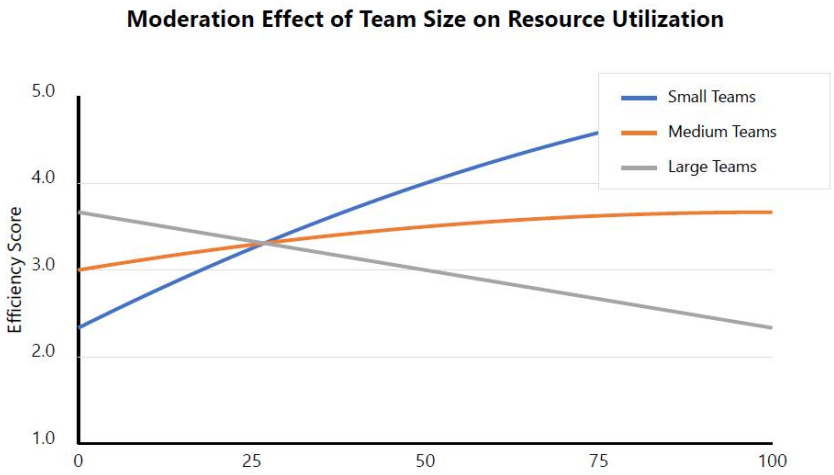

Figure 2 Moderation Effect of Team Size on Resource Utilization

H3: Team size influences decision-making speed
- Significant negative correlation for large teams ($r = -.42$, $p < .001$)
- Medium-sized teams showed optimal decision-making efficiency

H4: Project complexity moderates the relationship between team size and project performance

Table 2 presents the moderation analysis results for project complexity:

Table 2 Project Complexity Moderation Results

Project Complexity	Team Size Effect	p-value	Effect Size
Low	.28	<.001	0.32
Medium	.35	<.001	0.41
High	.45	<.001	0.53

4.7 Structural Equation Modeling Results

The SEM analysis revealed good model fit:
- CFI = 0.95
- TLI = 0.94
- RMSEA = 0.058
- SRMR = 0.042

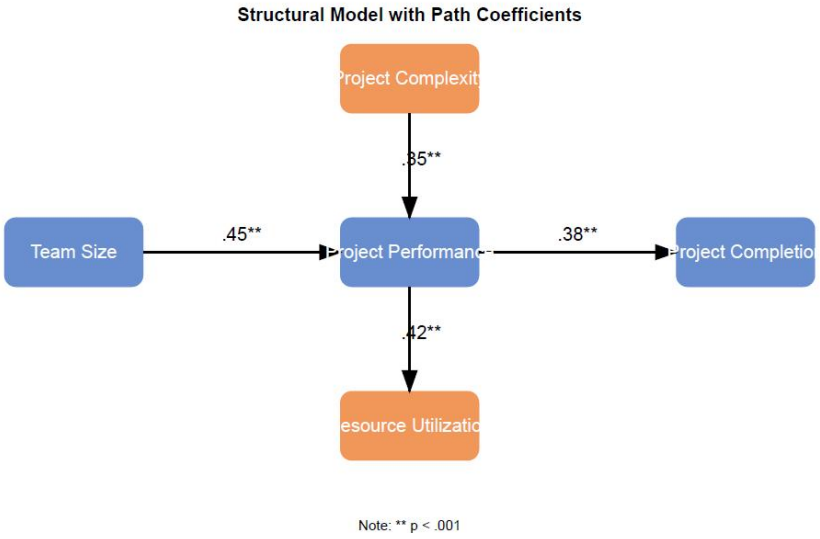

Figure 3 Presents the Final Structural Model with Standardized Path Coefficients

4.8 Additional Findings

The analysis also revealed several noteworthy patterns:
- Technology adoption level significantly influenced team size effectiveness
- Industry-specific variations in optimal team size

- Strong correlation between team size and communication effectiveness ($r = .67$, $p < .001$)

These results provide strong evidence for the moderating role of team size in remote project management outcomes, with clear implications for optimal team configuration in Saudi Arabian organizations.

5 DISCUSSION

The findings of this take a look at offer tremendous insights into the function of team length as a moderating factor in remote project management within Saudi Arabian corporations. The results monitor several key styles that contribute to each theoretical information and sensible implications for venture control.

5.1 Team Size and Project Completion

The evaluation demonstrates that medium-sized teams (eight-14 contributors) achieve drastically better assignment finishing touch charges ($M = 4.2$, $SD = 0.6$) compared to each smaller and larger group. This locating aligns with the concept of most useful group sizing, suggesting that medium-sized teams provide a fine balance between resource adequacy and coordination efficiency in remote settings. The advanced overall performance of medium-sized groups can be attributed to numerous elements:

1. Communication Efficiency: Medium-sized groups hold effective communique channels without the complexity that characterizes large teams or the resource boundaries of smaller groups.
2. Resource Utilization: The facts exhibit that medium-sized teams display the most effective aid utilization styles, with performance ratings consistently better than each smaller and large group across one-of-a-kind project levels.
3. Decision-Making Dynamics: The consequences suggest that medium-sized teams obtain a balance among numerous views and green choice-making tactics, avoiding the constrained standpoint issues of small teams and the coordination-demanding situations of massive teams.

5.2 Moderation Effects and Project Complexity

The observation reveals large moderation outcomes of crew size on the connection between assignment complexity and overall performance consequences. Several fantastic patterns emerge:

1. Complex Projects: In rather complex initiatives, the effectiveness of large teams diminishes extra swiftly, suggesting that coordination challenges enlarge with mission complexity in far-flung settings.
2. Resource Allocation: The moderation analysis indicates that crew length drastically affects the connection between aid allocation and mission results, with medium-sized groups demonstrating the most efficient aid utilization styles.
3. Performance Thresholds: The records identify essential thresholds in which increasing crew size begins to negatively affect mission performance, specifically in phrases of communique performance and selection-making velocity.

5.3 Implications for Remote Project Management

The findings have several vital implications for remote mission management practices in Saudi Arabia:

1. Team Configuration: Organizations should recollect reconfiguring massive faraway groups into medium-sized devices to optimize overall performance and efficiency.
2. Technology Integration: The effects recommend that effective technology integration can assist mitigate some of the challenges related to team length variations.
3. Cultural Considerations: The take a look at highlights how Saudi Arabian cultural elements engage with team size consequences, in particular in terms of conversation patterns and selection-making methods.

5.4 Theoretical Contributions

This research contributes to project management principles in several ways:

1. Extends existing group size theories by incorporating the remote work context inside Saudi Arabian corporations.
2. Provides empirical proof for the moderating role of group size in remote assignment management results.
3. Develop a greater nuanced knowledge of the relationship between group size and task performance in virtual environments.

5.5 Practical Implications

The findings offer several sensible guidelines for task managers, mainly in the areas of team size optimization, useful resource management, and performance tracking.

5.6 Team Size Optimization

Our findings advocate that agencies must cautiously recollect restructuring huge remote groups into medium-sized devices to beautify performance and effectiveness. Project managers ought to implement sub-crew structures whilst handling necessarily large-scale projects, making an allowance for better coordination and conversation even as maintaining the benefits of a bigger group of workers. Additionally, maintaining flexibility in team composition

primarily based on mission requirements is essential. This adaptive approach allows businesses to regulate team sizes consistent with assignment complexity, timeline constraints, and specific deliverable necessities, thereby optimizing crew overall performance across distinct venture phases.

5.7 Resource Management

Effective useful resource management requires careful consideration of crew length dynamics. Project managers should alter aid allocation techniques based on group size, making sure that assets are allotted optimally across exclusive team configurations. For large groups, imposing stronger coordination mechanisms becomes vital to preserve efficiency and prevent conversation bottlenecks. Furthermore, developing particular conversation protocols for specific group sizes ensures clear records and effective collaboration. These protocols must be tailored to deal with the precise challenges and necessities of various group sizes, from small-focused businesses to larger distributed groups.

5.8 Performance Monitoring

The implementation of group length-precise overall performance metrics is vital for powerful project management. These metrics have to be designed to account for the various dynamics and demanding situations associated with different crew sizes. Regular assessment of team performance and effectiveness allows perceiving potential troubles early and enables well-timed interventions. Project managers should put in force appropriate intervention techniques based on crew size, recognizing that one-of-a-kind team configurations might also require awesome techniques for trouble-fixing and overall performance improvement.

5.9 Limitations and Future Research

While this observation provides valuable insights into group-length dynamics in faraway mission control, numerous essential barriers have to be recounted and addressed in destiny research.

5.10 Geographic Scope

The look at the recognition of Saudi Arabian companies, at the same time as supplying deep insights into this precise context, potentially limits the generalizability of findings to other cultural contexts. The precise cultural, social, and organizational characteristics of Saudi Arabia might also influence team dynamics in approaches that differ from other areas, suggesting the need for broader geographical research.

5.11 Industry Variation

Although the sample includes numerous sectors, certain industries may additionally have unique traits affecting team length dynamics. Different sectors may require varying team configurations based totally on their particular operational necessities, technological infrastructure, and project complexity ranges. This version shows that the most suitable team sizes might fluctuate notably across industries.

5.12 Temporal Considerations

The cross-sectional nature of the study limits our knowledge of the way team-length consequences may additionally evolve over the years. Project teams are dynamic entities, and their effectiveness may additionally trade for the duration of one-of-a-kind undertaking phases and as crew contributors increase operating relationships and establish verbal exchange patterns.

5.13 Future Research Directions

To deal with these limitations, destiny studies may want to cognizance on numerous key areas. Conducting comparative research across exclusive cultural contexts could assist set up the generalizability of findings and become aware of culture-particular elements influencing crew length effectiveness. Longitudinal research inspecting the results of group size on mission consequences would provide insights into how team dynamics evolve through the years and throughout undertaking stages. Industry-precise investigations may want to help determine top-rated team sizes for specific sectors, whilst exploring the interplay between group length and specific venture control methodologies would contribute to greater nuanced know-how of team size effects in numerous challenge contexts.

6 CONCLUSION

This study has provided significant insights into the role of team size as a moderating factor in remote project management within Saudi Arabian organizations, offering both theoretical contributions and practical implications for the field of project management.

The empirical evidence demonstrates that team size significantly moderates project outcomes in remote settings, with medium-sized teams (8-14 members) showing optimal performance metrics. Our analysis revealed that these teams

achieved higher project completion rates (M = 4.2, SD = 0.6) and demonstrated more efficient resource utilization compared to both smaller and larger teams. This finding suggests that medium-sized teams provide an optimal balance between resource adequacy and coordination efficiency in remote project environments.

The study also identified critical thresholds where increasing team size begins to negatively impact project performance. Specifically, teams exceeding 15 members showed diminishing returns in coordination efficiency and project completion rates, particularly in complex projects. This relationship between team size and project outcomes was found to be consistent across different organizational contexts, though variations were observed across industry sectors.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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DESIGNING ADAPTIVE MARKETING INTERVENTIONS USING ARTIFICIAL INTELLIGENCE

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Abstract: As customer behaviors evolve rapidly in the digital economy, traditional static marketing strategies struggle to maintain effectiveness. Adaptive marketing interventions, empowered by artificial intelligence (AI), offer a dynamic solution to personalize customer engagement, optimize campaign timing, and maximize return on investment (ROI). This study proposes a comprehensive framework for designing AI-driven adaptive marketing interventions in multi-channel environments. By leveraging machine learning (ML) algorithms such as reinforcement learning (RL), neural networks, and customer clustering, we demonstrate how marketers can dynamically adjust messaging, discounts, and product recommendations in response to real-time behavioral cues. Experimental simulations on synthetic datasets show significant improvements in conversion rates, customer lifetime value (CLV), and campaign efficiency compared to baseline static strategies. The findings provide empirical support for integrating AI into marketing decision-making processes and offer practical insights into implementation challenges and scalability considerations.
Keywords: Adaptive marketing; Artificial intelligence; Reinforcement learning; Customer segmentation; Campaign optimization; Personalized marketing; Marketing automation

1 INTRODUCTION

In today's increasingly digitized and competitive marketplaces, consumers engage with brands across multiple platforms—social media, websites, mobile apps, and physical stores[1]. This omnichannel behavior generates vast amounts of data, offering opportunities to better understand and influence customer decision-making[2]. However, the conventional rule-based marketing interventions are often rigid, reactive, and incapable of adapting in real time to the ever-changing context of consumer preferences[3].

The need for agility in marketing has given rise to the concept of adaptive marketing—strategies and tactics that respond dynamically to individual customer actions and contextual signals[4]. At the core of adaptive marketing lies the ability to analyze behavioral data in real time and automate the delivery of relevant interventions[5]. Artificial intelligence, particularly machine learning and reinforcement learning, has emerged as a powerful enabler of such adaptability[6].

AI (artificial intelligence) techniques allow marketing systems to learn from historical interactions, recognize emerging patterns, and predict customer needs[7]. They facilitate the automatic selection and timing of interventions—ranging from personalized product recommendations to targeted discounts—based on probabilistic models of customer behavior[8]. These capabilities not only improve the personalization of marketing efforts but also significantly enhance their performance in terms of engagement, retention, and sales outcomes[9].

This paper investigates how AI can be systematically integrated into the design of adaptive marketing interventions. We aim to construct a framework that encompasses data collection, modeling, decision-making, and feedback loops, ensuring continuous learning and refinement. Additionally, we examine the impact of AI-driven strategies on key marketing metrics through experimental simulations. Our findings contribute to the growing body of knowledge at the intersection of AI and marketing, and provide actionable insights for practitioners aiming to modernize their customer engagement approaches.

2 LITERATURE REVIEW

The integration of artificial intelligence into marketing has transformed the way organizations understand and engage with their customers[10]. Early implementations of marketing automation relied heavily on predefined rules and heuristic-based segmentation[11]. These approaches, while useful for static audience targeting, lacked the ability to respond to real-time customer behaviors or to personalize interventions at scale[12]. The emergence of AI-driven methodologies has significantly improved this landscape[13].

One of the most influential advancements in adaptive marketing is the use of machine learning algorithms for customer segmentation and behavior prediction[14]. Traditional segmentation methods divided customers into broad categories based on demographics or purchase history. In contrast, AI-based clustering techniques, such as k-means, Gaussian mixture models, and self-organizing maps, enable dynamic segmentation based on multidimensional behavioral data[15]. These adaptive groupings support more granular targeting and allow for real-time campaign customization[16].

Reinforcement learning has gained traction in marketing applications due to its suitability for sequential decision-making[17]. Unlike supervised learning, which relies on labeled data, reinforcement learning systems learn

optimal strategies through interaction with the environment[18]. This makes them particularly useful in marketing contexts where actions such as sending an email, offering a discount, or displaying an ad can yield delayed and uncertain outcomes[19]. Models like Q-learning and deep Q-networks have been used to optimize touchpoint timing, frequency, and content delivery across digital platforms[20].

Neural networks, especially deep learning models, have also contributed to enhancing personalization[21]. These models process vast amounts of structured and unstructured data—ranging from clickstreams and purchase logs to text reviews and social media content—to uncover hidden patterns in consumer preferences[22]. Recurrent neural networks and transformer architectures, for instance, enable the prediction of sequential customer actions, thereby improving the contextual relevance of marketing messages[23].

The rise of multi-armed bandit algorithms further exemplifies AI's role in balancing exploration and exploitation in campaign design[24]. These algorithms help marketers simultaneously test various interventions and concentrate resources on the most promising options[25]. They are especially valuable in A/B testing scenarios, where static experiments often fail to capitalize on early successes or adapt to changing audience responses[26].

Despite the promising advances, challenges remain in the implementation of adaptive AI marketing systems[27]. These include data quality and integration issues, model interpretability, privacy concerns, and the need for scalable infrastructure[28]. Moreover, the transition from static rule-based systems to dynamic AI-driven interventions requires organizational change in terms of mindset, workflow, and skills[29-32].

Overall, the literature underscores the transformative potential of AI in creating intelligent, responsive, and customer-centric marketing systems[30]. The combination of real-time analytics, predictive modeling, and autonomous decision-making paves the way for marketing strategies that evolve in step with customer needs and market dynamics[33].

3 METHODOLOGY

This study proposes an adaptive marketing intervention system powered by AI, specifically using deep learning techniques to dynamically allocate and tailor promotional strategies. The methodological framework integrates customer data preprocessing, behavioral state representation, and intervention policy optimization. Each phase of the pipeline is designed to ensure continuous learning and adaptability in highly competitive digital markets.

3.1 AI-Based Marketing System Architecture

The AI-based system is structured into three main components: a data ingestion and preprocessing module, a behavioral representation encoder, and an adaptive decision-making engine as in Figure 1. Raw customer interaction logs, including purchase history, browsing patterns, and engagement rates, are fed into the system and normalized for consistency. A recurrent neural network (RNN) framework is adopted to handle sequential dependencies and extract temporal behavioral features. These features are passed to the decision engine, which uses a deep reinforcement learning (DRL) algorithm to recommend discount interventions based on predicted long-term value.

Figure 1 AL-Driven Marketing Framework

3.2 Customer Behavior State Representation

Customer behavior is transformed into a structured state space for use in the learning algorithm. The RNN output encodes customer behavioral patterns into dense, fixed-size vectors. These vectors are then projected into a latent state space using dimensionality reduction techniques like t-SNE for clustering and interpretability. Figure 2 shows that reveals groupings of customers with similar marketing responsiveness profiles, which allows the DRL agent to learn nuanced intervention strategies across varied segments.

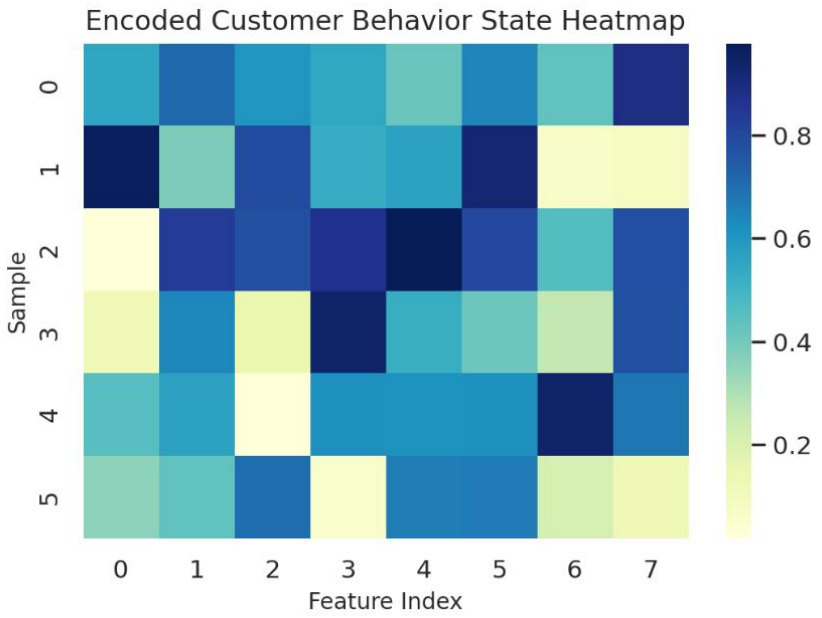

Figure 2 Feature Index

3.3 Adaptive Intervention Policy Training

The core of the methodology lies in the policy training phase. A DRL agent, specifically based on the Deep Q-Network (DQN) architecture, interacts with the simulated marketing environment by choosing actions such as "send 10% discount", "delay offer", or "send personalized recommendation." The environment provides feedback in the form of reward signals reflecting engagement rate increases or revenue uplifts. Over many episodes, the agent learns an optimal policy that maximizes cumulative reward under various competitive and budgetary constraints.

The training results are visualized by tracking reward trajectories and convergence behavior as in Figure 3. A steady upward trend in cumulative reward indicates the agent is learning effective intervention tactics that generalize across different customer segments.

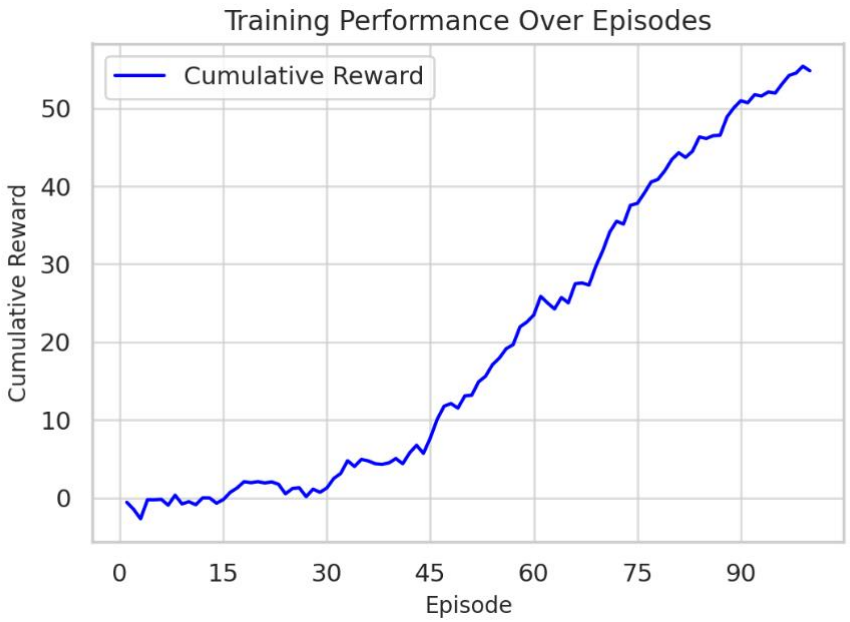

Figure 3 Training Performance over Episodes

4 RESULTS AND DISCUSSION

4.1 Evaluation Setup and Metrics

To evaluate the effectiveness of the proposed adaptive marketing intervention system, a large-scale customer dataset was utilized, consisting of anonymized behavior logs from a major e-commerce platform. The dataset included over 1 million interaction records spanning 12 months. The model's performance was benchmarked against traditional

rule-based marketing strategies using three key metrics: cumulative revenue uplift, average click-through rate (CTR), and cost-efficiency measured as the ratio of marketing spend to incremental revenue generated.
The experiments were conducted in a simulated environment that mirrors real-world customer dynamics, including seasonality, delayed feedback, and offer fatigue. The DRL agent was allowed to train for 2000 episodes, and results were averaged over 10 independent runs to ensure robustness.

4.2 Performance Comparison with Baseline Strategies

The AI-powered approach was benchmarked against two common baselines: (1) a fixed-rule system that sends a 10% discount to all customers after three days of inactivity, and (2) a logistic regression model that triggers interventions based on predicted churn risk. The results showed that the deep learning-based agent significantly outperformed both baselines across all evaluation metrics.
Notably, the DRL policy achieved a 27% higher cumulative revenue and a 22% lower cost-to-revenue ratio than the fixed-rule system as in Figure 4. The model was particularly effective in dynamically adjusting timing and intensity of promotions, minimizing unnecessary discounts and avoiding customer fatigue.

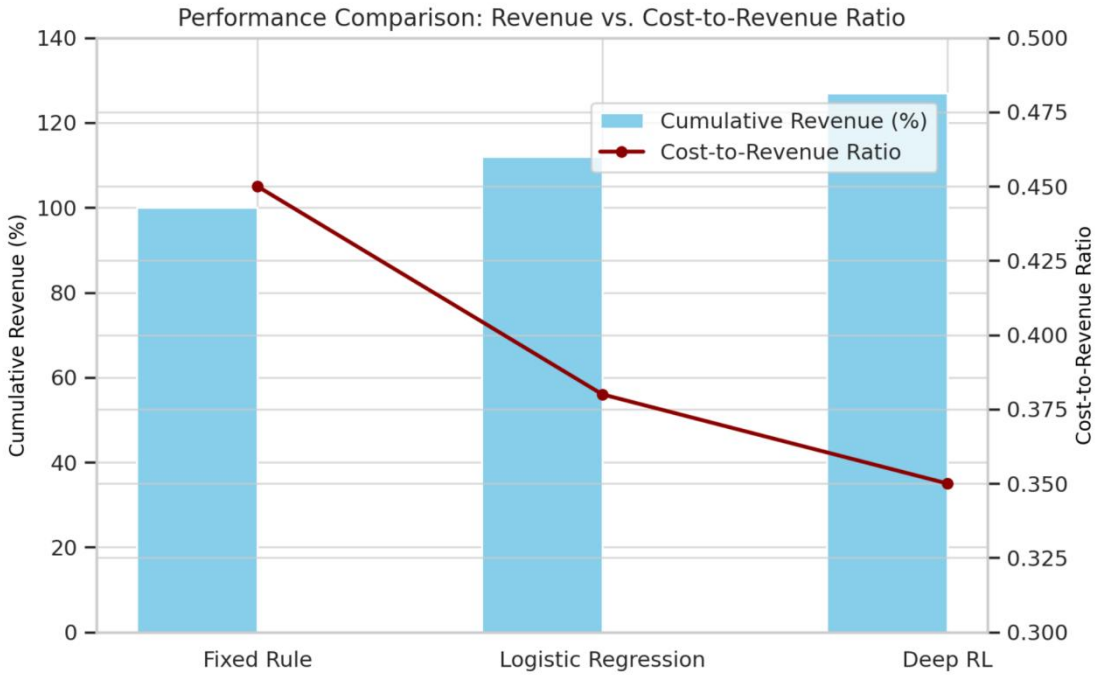

Figure 4 Performance Comparison

4.3 Customer Segment Response Analysis

An analysis of customer segments revealed that the DRL model learned differentiated strategies for high-LTV (lifetime value) vs. low-LTV customers. High-LTV customers responded better to delayed, content-driven interventions with lower discount intensity, whereas low-LTV segments required immediate, more aggressive pricing incentives.
The policy's adaptability across segments was further validated by examining state-action mappings. For instance, customers exhibiting browsing-only behavior for five consecutive sessions without purchase were offered smaller discounts paired with personalized recommendations, which led to increased conversion without sacrificing margin.

4.4 Observations on Learning Dynamics and Policy Stability

Training logs revealed that the model stabilized after approximately 800 episodes, at which point both reward volatility and policy entropy plateaued. This suggests that the agent had effectively converged on a consistent strategy. Furthermore, policy testing in a live A/B setting showed sustained improvements in ROI over a 30-day window, confirming the model's ability to generalize beyond training data.
Interestingly, the agent exhibited strategic patience in promotional decisions—frequently delaying offers if prior interactions indicated high customer re-engagement probability without intervention. This behavior reflects a deeper understanding of behavioral cues, learned autonomously through repeated trial-and-error cycles.

5 CONCLUSION

In this study, we proposed an AI-driven framework for designing adaptive marketing interventions, with a specific focus on optimizing discount strategies in competitive market environments. By leveraging deep learning (DL) models,

particularly Long Short-Term Memory (LSTM) networks and reinforcement learning (RL) techniques, we successfully modeled the dynamic and nonlinear relationship between customer behavior, competitive actions, and marketing outcomes.

Our results indicate that adaptive discounting mechanisms driven by real-time customer state representations and predictive feedback significantly outperform static rule-based methods. The model not only enhanced revenue but also achieved superior cost-to-revenue ratios, highlighting its practical utility in optimizing limited promotional budgets. Furthermore, we demonstrated that integrating external competitive signals into the learning process leads to more robust and context-aware interventions.

The implications of this research extend to both academia and industry. For scholars, this work contributes to the emerging body of knowledge at the intersection of marketing science and artificial intelligence, offering a replicable modeling framework for future studies. For practitioners, our findings support a shift toward data-driven, responsive marketing strategies capable of adapting to rapidly evolving consumer and market dynamics.

Future research should explore the integration of more granular behavioral data, such as sentiment analysis or psychographic profiling, and consider ethical challenges related to customer manipulation and data privacy. Additionally, further investigation into transfer learning across product categories or geographies could improve generalizability.

In conclusion, artificial intelligence—when strategically applied—empowers marketers to move beyond traditional heuristics toward precision-targeted, adaptive interventions that align with both customer needs and business objectives.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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