Article

Regional Comparison and Strategy Recommendations of Industrial Hemp in China Based on a SWOT Analysis

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Abstract: The hemp (Cannabis sativa L.) industry has great potential growth due to its multifaceted characteristics, however, challenged by the imbalance between the rapid agricultural production growth and the inadequate market. Against the manifesting functional overlapping and homogeneous competition among regions and nations, multi-regional synergistic development strategies of the hemp industry are critical for a sustainable agricultural-industrial system. To propose development strategies and R&D priorities of the hemp agricultural system for multi-regional synergistic development of the hemp industry. A nationwide survey and a SWOT analysis were carried out within five major production provinces in China, which is one of the largest producers of hemp, including Yunnan, Heilongjiang, Shanxi, Inner Mongolia and Jilin. Legislation, distribution, yield and utilization status and their effect on the development of industrial hemp in China were discussed. The SWOT analysis suggested that the negative effects of weaknesses and threats are stronger than the positive effects of strengths and opportunities. The modern hemp industry is still in an early phase of development characterized by the emerging legislation, growing acreage, initial researches and a few applications that pertain to mainstream use in China. Therefore, strategy recommendations, including top-level design, participating in global competition, promoting innovation and enhancing public cooperation, were proposed. We provide strategies for enhancing the hemp agricultural-industrial system, thus enabling policy makers and researchers to master the priority of promoting economic corporation and agricultural science and technology innovation.

Keywords: strategic planning; industrial hemp (Cannabis sativa); SWOT analysis; economic geographic feature; regional comparison

1. Introduction

Hemp (Cannabis sativa L.) is an important yet controversial plant with a long history of agricultural, recreational, medicinal and industrial uses with increasing academic, agricultural, pharmaceutical, and social interests [1]. As a multifaceted crop, hemp has been used for food (seed), fiber and medicine for over 12,000 years [2] but also legally restricted or even prohibited in most parts of the world for containing the intoxicating compound Δ^9-tetrahydrocannabinol (THC). Recently, the regulation of hemp has been changed in many countries and regions to end the prohibition of crop cultivation and the rapid expansion of hemp production impacted the global market [3]. Although there is a potential for significant growth of the world hemp market, it is necessary to balance the rapid production growth and market demand to enhance the sustainability of the industry in the long run. Viewed as a multipurpose crop, hemp production provides unique raw material for several fields which gives the opportunity to form cross-regional and cross-industrial alliances of the industry, especially among domestic regions. However, to our knowledge, no study has been conducted to propose a path for multi-regional synergistic development of the hemp industry.
China is one of the largest producers of hemp. According to statistical data from China Agriculture Research System for Bast and Leaf Fiber Crops, the total production area of hemp in China is $6.54 \times 10^4$ ha in 2020 (unpublished data) which is 88.9% of the total area of the world in 2018 (FAOSTAT, 2018). The hemp industry is characterized regionally in China at the provincial level. For example, extracting metabolites for medical and cosmetic use is the leading industry in Yunnan province, but harvesting seed and fiber for food and textile is the primed in Shanxi province. Despite the present geographical distribution of hemp industries in China, comprehensive utilization of hemp biomass overall regions becomes a main trend that brings functional overlapping and homogeneous competition among regions. Therefore, the coordinated and differentiated development strategies of the regional industries must be taken into consideration for improving the economic ecosystem of the hemp industry at the country level.

In this study, we first discussed the status of industrial hemp in China in four aspects: legislation, distribution, yield and utilization. SWOT analysis was performed based on an investigation in five major production provinces in China. Regional comparisons were conducted and synergistic development strategies were provided for decision makers and researchers involved in the hemp industry.

2. Status of Industrial Hemp in China

2.1. Legislation

It is important to distinguish the groups of *Cannabis sativa* L., specifically marijuana and industrial hemp, for cultivating legally. The content threshold of THC on a dry weight basis is widely used as the key indicator to separate the two distinct varieties. However, it varies among regions and countries. The THC content is limited to 0.2% by EU regulations (Council Regulation (EC) No. 1420/98) which is the strictest all over the world, while 1.0% in Mexico, 0.5% in Malaysia and 0.3% in most of the countries like America, Canada and East Asian countries. Industrial hemp is defined for varieties complying with the THC threshold of 0.3% according to the national agriculture standard (NY/T 3252.1, NY/T 3252.2 and NY/T 3252.3), released in 2018 by the Ministry of Agriculture and Rural Affairs of the People’s Republic of China.

The regulation of cannabis in China follows the country’s Law on Narcotics Control and the Single Convention on Narcotic Drugs, known as the 1961 Convention. The plant was cultivated only for fiber and seed in traditional production areas beyond the limitation of the 1961 Convention. Some regions prohibited the crop in consideration of narcotics control, such as Xinjiang and Ningxia according to the local anti-drug regulations. Some regions, such as Yunnan, tried to eliminate the crop for a similar reason but ceased because of the importance in folk culture and life. Thereafter, regulations turned to foster the industry by renewed varieties with low THC content and high fiber yield. Since 2003, Provisional Regulation on Industrial Hemp in Yunnan Province was announced and then in 2010, License for Industrial Hemp Production and Processing was announced by the government of Yunnan Province. The regulations declared the system of administrative examination and approval which made the production under full control of the Drug Control Bureau of Public Security Department. Processing of hemp flowers and leaves was first mentioned and permitted by government documents.

In 2017, an amendment of local drug control laws in Heilongjiang Province was conducted to regulate the production, processing and market of hemp. The document defines the crop as an annual herbal variety belonging to the *Cannabinaceae* family, *Cannabis* genus, certificated by the provincial agriculture administration under the regulation of the nation, dedicated to being used in fiber, food, health care, medicine, feed, construction material and other industrial fields. Individuals and companies are allowed to cultivate, market and process hemp with a self-regulatory system. It is necessary for keeping a record in public security organs at or above the county level within 10 days after the crop was planted, marketed or processed. Hazard-free treatment is required to manage residues collected during processing with THC content higher than the identification.
standard. For there is no certain THC content threshold given by the regulation terms, the national agriculture standard (<0.3%) is applied to Heilongjiang. However, processing of hemp flowers and leaves is not allowed at present due to the possible conflict between the local legislation and the 1961 Convention. Cannabis and cannabis resin was deleted from Schedule IV of the Single Convention on Narcotic Drugs (1961) on 2 December 2020, voted by Commission on Narcotic Drugs (CND). However, as a CND member, China vetoed and indicated a strict regulation on the crop. Subsequently, four categories of hemp materials, including Cannabis sativa fruit, Cannabis sativa seed oil, Cannabis sativa leaf extract and Cannabidiol (CAS No. 13956-29-1), were banned by the National Medical Products Administration of China on 26 May 2021, according to the Notice on Updating the Catalogue of Prohibited Cosmetic Raw Materials.

2.2. Distribution

China plays an important role in the global hemp industry as the origin center and the oldest domestication center of the plant [4]. According to FAOSTAT (excluding Canada), hemp, including fiber and seed, was cultivated globally on 73,727 ha, of which 8791 ha in China and 36,216 ha in Europe (Table 1). The land area was 31,537 ha in Canada (Source: Health Canada) and 36,422 ha in America (Source: United States Department of Agriculture) [5]. However, the production area in China was seriously underestimated according to our domestic statistics. An investigation was conducted in five major production provinces including Yunnan, Shanxi, Inner Mongolia, Heilongjiang and Jilin in 2020 in this study and more precise data of hemp production area was obtained. Totally, $6.54 \times 10^4$ ha hemp was cultivated in China with distinct aims of raw material production (Table 2). As a result, China is the largest producer of industrial hemp in the world.

The hemp industry showed an obvious territorial distinction on the aimed products. Hemp was cultivated for both fiber and seed in Shanxi and Jilin, while all the plants were harvested for fiber in Heilongjiang and all for seed in Inner Mongolia. Hemp was also cultivated for fiber and seed in Yunnan in previous years. However, the industry has shifted to harvest flowering heads and leaves for extracting cannabidiol (CBD) since 2003 benefiting from the local legislation which made it possible to industrialized production and processing of endocannabinoids.

Table 1. Global production of hemp in 2018. Data of America were collected from the United States Department of Agriculture (USDA). Data of Canada were collected from Health Canada for the year 2018. Data of the other countries were collected from FAOSTAT for the year 2018. Total production area may be smaller due to repeated statistics of the dual-purpose hemp that is cultivated for fiber and seed simultaneously. Total land area of seed and fiber is the sum of collected data.

| Country      | Data Source | Seed (ha) | Fiber (ha) | Total (ha) |
|--------------|-------------|-----------|------------|------------|
| World Total  | USDA        | 32,140    | 41,587     | 141,687    |
| America      | Health Canada | -        | 36,422     |            |
| Canada       | -           | 31,537    |            |            |
| North Korea  | FAOSTAT     | -         | 21,457     | 21,457     |
| France       | FAOSTAT     | 16,511    | 773        | 17,284     |
| China        | FAOSTAT     | 4342      | 4449       | 8791       |
| Russia       | FAOSTAT     | 4691      | 3262       | 7953       |
| Chile        | FAOSTAT     | 2660      | 4386       | 7046       |
| Romania      | FAOSTAT     | 799       | 1996       | 2795       |
| Ukraine      | FAOSTAT     | 1133      | 1480       | 2613       |
| Hungary      | FAOSTAT     | 1606      | 254        | 1860       |
| The Netherlands | FAOSTAT | -         | 1812       | 1812       |
| Austria      | FAOSTAT     | -         | 714        | 714        |
| Italy        | FAOSTAT     | -         | 670        | 670        |
| Czechia      | FAOSTAT     | -         | 216        | 216        |
| Iran         | FAOSTAT     | 193       | -          | 193        |
| Spain        | FAOSTAT     | 140       | 19         | 159        |
| Poland       | FAOSTAT     | 59        | 80         | 139        |
| Turkey       | FAOSTAT     | 6         | 10         | 16         |
| South Korea  | FAOSTAT     | -         | 9          | 9          |
| Japan        | FAOSTAT     | -         | 1          | 1          |
Table 2. Provincial distribution of industrial hemp in China according to the investigation conducted by China Agriculture Research System for Bast and Leaf Fiber Crops in 2020. Other regions mainly include Guangxi, Anhui and Gansu, etc.

| Province     | Fiber ($\times 10^4$ ha) | Seed ($\times 10^4$ ha) | Flowering Heads ($\times 10^4$ ha) | Total ($\times 10^4$ ha) |
|--------------|--------------------------|-------------------------|-----------------------------------|--------------------------|
| Shanxi       | 1.07                     | 1.00                    | -                                 | 2.07                     |
| Heilongjiang | 1.95                     | -                       | -                                 | 1.95                     |
| Yunnan       | -                        | -                       | 1.33                              | 1.33                     |
| Inner Mongolia| -                       | 0.67                    | -                                 | 0.67                     |
| Jilin        | 0.09                     | 0.05                    | -                                 | 0.13                     |
| Other regions| 0.39                     | -                       | -                                 | 0.39                     |
| Total        | 3.50                     | 1.72                    | 1.33                              | 6.54                     |

2.3. Yield

The average hemp fiber and seed yield of China were 2837.5 and 2722.9 kg/ha, respectively, in 2018 according to FAOSTAT (Table 3). The data was almost the same as the results in our investigation. There was a huge yield gap between China and developed European countries in hemp fiber production, such as the Netherlands, Italy and Austria. However, it was nearly twice the world average. The seed yield was 61.25% of the world average in China, which was much lower than France and Spain. Considering the large land area for hemp production, it is necessary and helpful as a guarantee of stable supply of hemp materials by closing the yield gap between China and the advanced countries [6].

Table 3. World’s hemp production in 2018. Data obtained from FAOSTAT. The mean yield of the world was calculated by the average of the countries in the table for no details about the production of fiber and seed was collected from America and Canada.

| Country              | Fiber kg/ha | Fiber t  | Seed kg/ha | Seed t  |
|----------------------|-------------|----------|------------|---------|
| World average        | 1458.6      | 60,657   | 4445.7     | 142,883 |
| France               | 1660.3      | 1283     | 7592.6     | 125,362 |
| China                | 2837.5      | 12,623   | 2722.9     | 11,822  |
| Russian Federation   | 384.9       | 1256     | 451.3      | 2117    |
| Chile                | 945.4       | 4146     | 576.4      | 1533    |
| Spain                | 1059.7      | 20       | 5357.1     | 750     |
| Ukraine              | 474.7       | 703      | 525.8      | 596     |
| Hungary              | 1143.4      | 290      | 242.9      | 390     |
| Iran                 | -           | -        | 1026.9     | 198     |
| Romania              | 1438.9      | 2872     | 104.6      | 84      |
| Poland               | 636.5       | 51       | 473.4      | 28      |
| Turkey               | 877.8       | 9        | 500        | 3       |
| Czechia              | 2903.9      | 628      | -          | -       |
| South Korea          | 694         | 14,891   | -          | -       |
| Italy                | 6911.9      | 4631     | -          | -       |
| Japan                | 845.1       | 1        | -          | -       |
| The Netherlands      | 7642.9      | 13851    | -          | -       |
| North Korea          | 1655.2      | 14       | -          | -       |
| Austria              | 4742.6      | 3388     | -          | -       |

2.4. Utilization

A schematic diagram of industrial hemp utilization in China was provided in Figure 1. Fiber, seed and cannabinoid, which weigh no more than 1/3 of the above-ground biomass, are major aimed products in the hemp industry in China. Therefore, large amounts of residues would be gathered. There is an increasing quantity of byproducts with the growing land area for hemp production and the effective utilization of by-products is considered to be a bottleneck for raising revenue and reducing costs in the industry. Scraps of core stem are a major by-product during initial handling. However, an obvious functional overlap is detected in by-product utilization. Scraps are regarded as low value-added byproducts due to the low profit status in downstream industries, mainly involved in tray making and mushroom culturing.
3. Methodology

3.1. Research Structure

A modified research structure was developed with reference [7]. The research is divided into two parts (Figure 2). Research questions were developed at first and then data was collected by a survey conducted in the five major production provinces located in north (Inner Mongolia, Heilongjiang and Jilin), middle (Shanxi) and south (Yunnan) China. Applying SWOT analysis to each province, which is the acronym stands for Strengths, Weaknesses, Opportunities and Treams, is a common approach used to analyze strategic cases in the strategic management process [8]. The factors that affected industry development are identified into internal (“S” and “W”) and external (“O” and “T”) sectors and used to seek a fit between the two perspectives [9]. The SWOT analysis was adopted widely at single enterprise [10], industry [11], regional [12] and also cross-national level [13,14]. The approach was successfully used in agricultural aspects in recent years for constructing a map of suitable areas for introducing new crops [15] and for creating a competitive market for organic farming [16], etc.
After SWOT analysis was operated on each province, a provincial level comparison was adopted. Finally, strategy recommendation for the national development of industrial hemp was discussed.

3.2. Subjects of the Investigation

Subjects of the investigation included companies, government offices, farmers, universities and scientific institutions involved in the hemp industry. We mainly used field visits and meetings to collect data and wrote research reports for each province. Reports were collected mainly from five professors as below:

(1) Professor Yang Ming (worked in Institute of Economic Crops, Yunnan Academy of Agricultural Sciences),
(2) Professor Kang Hongmei (worked in Institute of Economic Crops, Shanxi Agricultural University),
(3) Professor Wu Guangwen (worked in Institute of Economic Crops, Heilongjiang Academy of Agricultural Sciences),
(4) Professor Ren Longmei (worked in Special Crops Institute, Inner Mongolia Academy of Agricultural & Animal Husbandry Sciences),
(5) Professor Feng Tong (worked in Economic Plants Research Institute, Jilin Academy of Agricultural Sciences).

3.3. Question Development

Research questions of this study were developed from the four basic aspects of SWOT analysis, as follows:

Question 1 (Strengths): What are the advantages and benefits of the province when adopting and developing the hemp industry?

Question 2 (Weaknesses): What are the weaknesses of the province when adopting and developing the hemp industry?

Question 3 (Opportunities): What are the opportunities of the province when adopting and developing the hemp industry?

Question 4 (Threats): What are the threats of the province when adopting and developing the hemp industry?

4. Provincial Comparisons Based on SWOT Analysis

4.1. Yunnan

4.1.1. Strengths (S)

In 2014, a production line for high purity CBD extraction, which was the first realizing industrial scale in the world, was built and put into production by Hankang (Yunnan) Biotechnology Limited Company. Taking Hankang Ltd. as a pilot, Yunnan made efficient use of the policies for routine management. Based on the stable and transparent legal environment, Yunnan became the center of hemp flowering tops and leaf processing and the only region in which CBD can be extracted, processed and marketed legally in China. As a consequence, Yunnan obtained much more research investment funds than other provinces in the wake of the CBD industry and a mature industrial cluster was established. Nearly 160 new companies related to hemp businesses had been founded in Yunnan from July 2018 to July 2019 [17]. Commercialized scientific research was stimulated by the quickly increasing investment.

4.1.2. Weaknesses (W)

The productivity of hemp cultivation was limited by lacking machines and the farming operations depended on manpower. Meanwhile, the dry matter CBD content in dominant varieties was up to 1.33% (Yunma NO.8), which was far below Felina 32 (7.6 ± 1.5%) cultivated in Italy [18]. The low CBD content implied the low efficiency in production, especially in the agriculture sector for most of the costs came from labor and agricultural consumables. Although news reported that a variety with CBD content of 4.29% (Zhong-
4.1.3. Opportunities (O)

There are opportunities for hemp industry development in Yunnan for the formed competitive advantages in the world’s cannabinoid market and potential new markets with new applications. While the regulatory and legal environment is evolving all over the world, legal use of CBD and allied active substances are recognized widely as a promising industry [19–21].

4.1.4. Threats (T)

The CBD industry is at risk under global competition for the gap of bio-extraction efficiency among regions is decreasing and the CBD exports will be challenged by products from other regions. CBD production is also challenged by the chemical synthesis industry [22]. As the CBD markets maturing, exploring featured products integrated with CBD and allied active substances, especially based on territorial and climatic specificity, would be a promising way in Yunnan.

4.2. Shanxi

4.2.1. Strengths (S)

Industrial hemp was mainly cultivated for fiber and seed in Shanxi (Figure 3A). As the companies involved in textiles, food and biomedicine went into the hemp industry, multi-products were developed and the industry was characterized by industrial diversity, which was important in improving regional-industrial structure [23,24]. The hemp industry was strengthened by the existing enterprises, especially in textile and seed processing. Shanxi Greenland Textile Co., Ltd. is the largest hemp textile company in China and its products are exported to more than 10 countries. Shanxi Tianhe Green Food Co., Ltd., equipped by two production lines with a capacity of 2000 t of seed-oil and seed-protein, is the largest industrial hemp oil producer in Northern China.

![Figure 3. Three cultivation patterns of industrial hemp implemented in China. (A) Traditional pattern with precision drilling and thin planting. (B) High-density-dwarfed-plant pattern with a density of 300–500 plants/m². (C) Wheat and hemp intercropping. Typically, alternate rows are arranged as 7 strips of spring wheat with a 230–250 cm width and 2 strips of hemp with a 60–70 cm width. The major farming concerns of hemp cultivation in China was provided in Supplementary Materials File S1).](image)

4.2.2. Weaknesses (W)

However, the development of the hemp industry in Shanxi was retarded mainly for two reasons: (1) lacking legislation in cannabinoid extraction and processing, which resulted in being unable to access the emerging CBD industry; (2) the mountainous topographic feature, which raised the barrier of efficiently mechanized production.
4.2.3. Opportunities (O)

Given the circumstances of global trends in multi-purpose hemp industry, Shanxi has the first move advantage in industry agglomeration in multi-purpose hemp industry. As people’s living standards rise and concern for life and health increases, especially China is going to nurture a strong domestic market and establish a new development pattern, industrial hemp in food, medicine and high-quality textiles will release great economic value and potential.

4.2.4. Threats (T)

Due to the lack of regional regulation, crop production is prone to disorder, which increases regulatory costs and has regulatory blind spots. The brand effect of industrial hemp products is insufficient, so it is vulnerable to competition from homogeneous companies. The industry was challenged by multi-directional competition [25].

4.3. Heilongjiang

4.3.1. Strengths (S)

Located in the northeast plain, the hemp cultivation in Heilongjiang province is highly mechanized due to the flat terrain. The hemp is now developed as an alteration of flax, which has been one of the pillar industries in the province with a capacity of 50,000 t of flax fiber and 31,250 t of linen yarns. Using existing, modern equipment for flax is a straightforward approach to develop a viable hemp-for-textile chain [26] and this approach is successfully implemented in Heilongjiang. A high-density-dwarfed-plant cultivation technique has been developed for acquiring similar farming management and processing performance as flax (Figure 3B). The density is 300–500 plants/m² which is 10–20 times higher than traditional practice and the average plant height is reduced to 1.5–2 m high, which is about 50–70% of the traditional practice.

4.3.2. Weaknesses (W)

One of the bottleneck constraints of the hemp-for-textile industry is the instable quality of dew retted fiber influenced by the inconstant climate and prolonged retting procedure. However, the chemical retting methods are not recommended for its high cost of sewage treatments. High-density cultivation pattern for industrial hemp in Heilongjiang requires large quantities of seeds, but the supply of seeds in this province is insufficient.

4.3.3. Opportunities (O)

Compared with other natural fibers, industrial hemp fiber, especially from Heilongjiang province, has unique performance and high yield, with a potential for new green packaging raw materials, which create an emerging market for industrial hemp. Except for textile products, the comprehensive utilization of hemp biomass is still at an early stage in Heilongjiang.

4.3.4. Threats (T)

Legal processing of flowering tops of hemp is still ambiguous due to the contradiction between the need of economic development and drug regulation. Meanwhile, there has not been a strong brand recognition which reduced the competitive ability in hemp-for-textile chains.

4.4. Inner Mongolia

4.4.1. Strengths (S)

Hempseed is widely used as nut snacks in northwest China. Inner Mongolia is an important producer of hempseed for its large-scale plain and gentle slope field for hemp cultivation. The wheat and hemp intercropping system is extensively conducted in Inner Mongolia for it can provide a greater yield than sole crops (Figure 3C). This farming system is valuable for further study and development which offers opportunities for the sustainable intensification of agricultural production [27].
4.4.2. Weaknesses (W)
Lacking funds caused a negative effect on the development of the hemp industry in Inner Mongolia, although the official support for industrial hemp research was initiated in recent years. The low seed holding capacity of varieties, low efficiency in bird control and shortage of machines decreased the benefits sharply through the grain loss and labor cost. Bird control methods, such as using alarm calls and netting, were applied only in small-scale areas for the costly infrastructure [28].

4.4.3. Opportunities (O)
The province has opportunities in developing industrial hemp for steady traditional demand and the upturn of the hempseed market.

4.4.4. Threats (T)
The variety must be improved and the intensive processing of seed urgently needs to be enhanced for only low doorsill existed in the agricultural production step.

4.5. Jilin
4.5.1. Strengths (S)
One definite advantage of industrial hemp in Jilin is the more suitable climate and geographic latitude for seed production than in Heilongjiang. The industry is considered to have a bright opportunity credited with the existed textile industry, especially with the Northeast Hosiery and Textile Industry Park Development Co. Ltd., the largest site for sock producing in the world.

4.5.2. Weaknesses (W)
The hemp industry is at an initial stage for lacking a complete industry chain in the province and the primary agricultural products, including seed and fiber, are sold to companies in Heilongjiang. The dew retting result is not stable and the fiber quality is not uniform compared to chemical retting.

4.5.3. Opportunities (O)
Jilin still offers excellent potential for the hemp industry through collaborations with the local sock industry and cross-regional cooperation while the legal requirements are met and the efficiency of retting is improved.

4.5.4. Threats (T)
The Political Consultative Conference of Jilin province proposed local legislation in regard to industrial hemp production in 2018. Although the local government sent a strong positive signal to the legislation, no final conclusion has been made. Thus, hemp is cultivated only for fiber and seed in Jilin.

5. Discussion and Recommendations for Hemp Industry Development in China
5.1. Economic Geographic Feature of Hemp Industry in China
The SWOT analysis suggests that the modern hemp industry is still in an early phase of development characterized by emerging legislation, growing acreage, initial researches and a few applications that pertain to mainstream use in China. However, the economic geographic feature of the hemp industry in China is characterized by industrial diversity, which is considered to be beneficial to the promotion of resource efficiency and system resilience [29]. Specifically, the industry diversifies into three levels: geographic distribution, industrial models and leading products.

Hemp has wide ecological adaptability and is distributed from 18° to 53° north latitude in China spanning more than 4000 km. As discussed above, the five provinces difference in photoperiod, climate, landscape, soil quality, economic development and even lifestyles. Based on the huge differences among regions, relevant industrial models
were developed, characterized as SIAM (spontaneous industrial agglomeration model) in Yunnan, Inner Mongolia and Shanxi, GIPM (government-led industrial park model) in Jilin, and EIAM (exogenous industrial agglomeration model) in Heilongjiang. As a consequence, the leading products varied among regions. The industrial diversity raised the potential of cross-regional cooperation and higher profits within synergies.

However, two problems must be noted: (1) for that geographic heterogeneity is an important determinant of economic activity at country-level [30], a more heterogeneous spatial distribution of hemp industrial activities might in turn harm overall national outcomes; (2) along with the development of the industry, the importance of multiuse of hemp biomass was lifted to a higher level on the regional development schedules which was bound to convergence and to eliminate the regional synergistic effects and diversity. Decision makers should take the paradox into consideration for enhancing the synergy and avoiding excessive internal competition.

In addition, except for fiber materials, the cross-regional exchange of technologies, specialized equipment, flower/leaf materials and seeds were blocked due to the local protectionism, legislations and geographic isolation. A new setup highlighted by innovation-driven has not been formed and hence, blockades on primary technologies are the first to be chosen to maintain the competitive advantage. As the loss of the first move advantage, seeking cooperation and mutual complementarity would be beneficial for the sustainable development of the industry [31,32]. Multilateral regulation of hemp material transfer is needed when cannabis resin is involved. On the agronomy aspect, photoperiod sensitivity of hemp is the major obstacle of plant introduction, especially in field production, which requests for regionalized varieties.

5.2. Strategy Recommendations for Hemp Industry in China

5.2.1. Formulating National and Regional Strategy

The global market for products derived from hemp is anticipated to grow greatly due to the multifaced nature [3]. However, the hemp industry is challenged by political, economic, industrial and technological factors as we discussed above. According to the results of the SWOT analysis, it is obvious that the negative effects of weaknesses and threats are stronger than the positive effects of strengths and opportunities. Therefore, as the growing acreage all over the country, development strategies are needed for enhancing the sustainability of the industry and avoiding serious homogenization of competition, especially under the existed restrictions in the use of natural and social resources [33].

Regarding the importance of the economic role of local governments in industrial development in China, sharing an optimal division and cooperation system would lead to new opportunities for enhancing synergistic effects and international competition.

The great socio-political effects on the crop should be primarily taken into consideration so as to avoid political interrupting of the industry. Any narcotic case involved in agricultural hemp production might be fatal to the industry in China. At present, the country formulated two lines for hemp regulation: (1) the law-line, including the international convention, national law on narcotics control, local legislation and enterprise system; (2) the standard-line, including the industrial standard, provincial standard and enterprise standard. The two lines guarantee the security and legality of the hemp industry at the provincial level. However, lacking cross-regional regulation of hemp resource exchange impeded the synergy of provinces. We suggested that a pilot scheme should be launched by local governments for designated enterprises attempting to exchange hemp resources. Thereafter, a universal regulation system should be proposed for more efficient and open control at the national level.

In the aspect of products, the five provinces have formed their own strengths and leading products (Figure 1, Table 4), but the multiuse of hemp biomass and multi-products route has already become a major trend under the pressure of increasing supply and reducing the price of a single product. In addition, the hempseed and fiber industry face challenges from other oilseed and fiber crops, such as rapeseed, linseed, sesame, cotton and ramie. Therefore, more intensive managements are required for sustainable development of the hemp industry. The hemp Industry Association of Yunnan Province
was founded on 26 October 2020. It consisted of seven departments including science and technology R&D center, extraction and synthesis center of cannabinoids, enterprise center, technology transformation center, trading center, product exhibition and exploration center, and inspection center. The aim of the association is to develop the biomedicine and health industry by forging the complete hemp industry chain to value chain. It is an important action in promoting integrative management. However, it is short of an overall planning on cross-regional cooperation and resources agglomeration. We suggest that regional structure and historical development should be thoroughly considered at the country level.

5.2.2. Enhancing Global Competition

Facing the fiercer international competition in the CBD industry, Europe and America are shifting their planting targets and focus on CBD considered to have substantial potential as a pharmaceutical [34]. At present, dual cultivars that are not only rich in CBD but also produce considerable oilseeds are being employed in these regions. Additionally, as an above-average energy crop with a large potential for yield improvements [35], the use of hemp biomass represents considerable competition. As a result, the development strategy in China cannot be established ignoring global competition, especially product market competition, according to the inadequate market expansion and rapidly growing production.

The sustainability of industrial hemp is affected by the competition-fragility and competition-stability dynamics [36]. Lower production cost, higher product quality, richer product experiences and more efficient market managements are key in global competition. China is able to produce competitive hemp materials due to lower labor costs than North America and Europe. However, this advantage is vanishing along with the growing acreage in less developed countries and increasing yield in developed countries. Considering the existed huge yield gap between China and advanced countries (Table 3), breed improvement and efficient cultivation techniques are in urgent demand in reducing production costs. Quality evaluation of hemp products lacks comprehensive criteria covering the four kinds of raw materials and thousands of applications. Although hemp products are widely involved in security, health, environment and other aspects of human life, existing standards are limited mainly in the textile industry (Supplementary Materials File S2). The standardization effort is expected to carry forward throughout the industry chain.

Product market competition has been identified as one of the most powerful corporate governance tools for maximizing industrial value [37]. In the face of competition threats, strategies promoting product innovation and capturing market share are encouraged for enhancing product market competition [38]. The relationship between product market competition level and innovation activities is not monotonic [39] containing variables within R&D investment, information asymmetry, trade secrecy, market access and risk, external competition, industrial collaborative agglomeration and so on [40]. However, a higher level of R&D and innovation is widely supported by empirical evidence and academic literature. Hence, an orderly change to a more open view in global competition and innovation are desired in the hemp industry of China.

5.2.3. Promoting Science and Technology Innovation

Innovation plays an important role in promoting sustainable development in both emerging and developed industries [41]. Any innovation is the result of a complex set of relationships within a system of individuals and groups, science and policy, profit and share, information and supply [42]. Therefore, a priority of science and technology innovation should be proposed under the constraint of resources. In this study, we represented a priority on agricultural science and technology R&D in the hemp industry of China based on the understanding of the SWOT analysis (Table 5). Four priority areas were given covered quality, yield, and economic and environmental efficiency. The priority areas were subdivided into particular research tasks as topics for launching R&D programs.
Table 4. SWOT analysis of five major hemp production provinces in China.

| Provinces   | Internal                                      | External                                      | T (Threats)                           |
|-------------|-----------------------------------------------|-----------------------------------------------|---------------------------------------|
| Yunnan      | • Steady increase in research investment      | • Costs reductions                           | • Excessive competition               |
|             | • Local legislation and political stability   | • High CBD content varieties                  | • Export-dependence                   |
|             | • Mature industrial cluster                   | • Low barriers in plant extraction technology |                                       |
|             | • Underdeveloped biomedical products          | • Underdeveloped biomedical products          |                                       |
|             | • Low barriers in plant extraction technology | • Underdeveloped biomedical products          |                                       |
| Shandong    | • Public awareness                            | • Lack of fund                                | • Multi-directional competition        |
|             | • Public awareness                            | • Mountainous areas                           |                                       |
|             | • Advantages in deep processing products      | • Lack of local legislation                   |                                       |
| Heilongjiang | • Similar producing model as flax             | • Instability in rain and dew retting         |                                       |
|             | • Tradition advantage in textile              | • Comprehensive utilization                   |                                       |
|             | • Advantages in deep processing products      | • New markets in replacing flax               |                                       |
| Inner       | • Mass base in hemp cultivation and utilization as nut snacks | | Future legal requirements |
| Mongolia    | • High efficiency in wheat/hemp intercropping | • Lack of funds                              | | Brands |
| Jilin        | • Suitable climate for seed production       | • Lack of complete industry chain             | | |
|             | • Existed textile industry                    | • Unstable quality and efficiency in retting  | | |

Table 5. Specific advancements needed to improve global competition of hemp industry in agricultural sector in China.

**Quality (Low Content of Nutritional and Functional Components in Raw Materials)**
1. Improve content of nutritional and functional components, including CBD, oil, protein, cellulose, polysaccharide, etc.
2. Improve content of specific chemicals consisted in Chinese varieties, including cannabigerol (CBG) and cannabinol (CBN), and regional planting of the varieties
3. Improve the structure of functional components for easier processing
4. Proposing new breeding aims to create new supply, especially in biomedicine and health products

**Yield (Huge Yield Gap Between China and Advanced Countries)**
1. Improve per unit yield of agro-products by breed improvement and modern cultivation techniques
2. Introducing integrative farming system for improving comprehensive output, such as intercropping and protected agriculture
3. Dealing with the effects of underlying hazardous climate events on crop production
4. Improving seed shattering resistance and consistency in crop maturity
5. Improving efficiency of sex identification of seed and crop population construction

**Economic Efficiency (High Labor Cost, Fragmented Planting Distribution and High Post-Harvest Loss)**
1. Reducing labor cost by promoting whole-process-mechanized production
2. Expanding the proportion of large-scale production for enhancing scale benefit and adapting the needs of mechanized production
3. Improving techniques at postharvest stage, especially for stable rain and dew retting, avoiding mildew of primary products

**Environmental Benefits (Rational Use of Natural Resources)**
1. Introduction of green techniques in farming for reducing impacts of chemical fertilizer application and water consumption
2. Enhancing the adaptability of the crop on poor soil in marginal lands, such as arid regions, saline and alkaline lands, etc.
5.2.4. Enhancing Government and Public Cooperation

Science and technology innovation of industrial hemp was hindered by lacking funds and applicable laws for a long time in China. However, with the rapid development of human society, ensuring the effective maintenance of common resources has become a global challenge and the investment in hemp innovation ought to be more efficient for compensating the long inadequate inputs. Hence, promoting public cooperation among countries, regions, and individuals is key to facing the challenge. Since 2008, China Agriculture Research System (CARS) for Bast and Leaf Fiber Crops was established under the guidance and financial support of Ministry of Agriculture and Rural Affairs of China and Ministry of Finance of China. 20 research teams were set up by CARS in order to supply scientific support for the hemp industry (Table 6). The CARS covered almost the whole chain of hemp agriculture and became the key power of science and technology R&D in the field of industrial hemp in China. For example, industrial hemp varieties bred by CARS, including Yunma NO.7, Qingdama NO.1, Fenma NO.3, Jinma NO.1 and Zhongdama NO.1, covered more than 70% of the acreage of China at present (unpublished data). Despite the profound improvement in agriculture sector made by CARS, its effectiveness was weakened by lacking teams involved in end-product R&D.

Table 6. Major teams involved in industrial hemp R&D in China, supported by China Agriculture Research System (CARS) for Bast and Leaf Fiber Crops.

| Numbers | Teams | Supporting Institutions | Coverage Regions |
|---------|-------|-------------------------|------------------|
| 1       | Germplasm Resources of Bast Fiber Crops | Institute of Bast Fiber Crops, CAAS | The whole country |
| 2       | Breeding Techniques of Bast Fiber Crops | Institute of Bast Fiber Crops, CAAS | The whole country |
| 3       | Industrial Hemp Breeding | Yunnan Academy of Agricultural Sciences | The whole country |
| 4       | Industrial Hemp Physiology and Cultivation | Yunnan University | The whole country |
| 5       | Weed Control and Comprehensive Plant Protection | Hunan Academy of Agricultural Sciences | The whole country |
| 6       | Disease Control | Nanjing Institute of Agricultural Mechanization | The whole country |
| 7       | Mechanization of Planting | Ministry of Agriculture and Rural Affairs | The whole country |
| 8       | Mechanization of Harvesting | Institute of Bast Fiber Crops, CAAS | The whole country |
| 9       | Processing of Bast Fiber Film | Institute of Bast Fiber Crops, CAAS | The whole country |
| 10      | Performance Modification of Bast Fiber | Donghua University | The whole country |
| 11      | Comprehensive Utilization of Byproducts | Institute of Bast Fiber Crops, CAAS | The whole country |
| 12      | Biological Degumming | Hunan University | The whole country |
| 13      | Industrial Economy | Hunan University | The whole country |
| 14      | Daqing Industrial Hemp Station | Heilongjiang Academy of Agricultural Sciences | Heilongjiang Province |
| 15      | Fenyang Industrial Hemp Station | Shanxi Agriculture University | Shanxi Province |
| 16      | Lu’an Industrial Hemp and Kenaf Station | Academy of Agricultural Sciences of Lu’an City | Anhui Province |
| 17      | Yuanjiang Station of Bast Fiber Crops | Institute of Bast Fiber Crops, CAAS | Hunan Province |
| 18      | Dali Industrial Hemp and Flax Station | Institute of Agricultural Sciences of Dali Bai Autonomous Prefecture | Part of Yunnan Province |
| 19      | Xishuangbanna Industrial Hemp Station | Institute of Agricultural Sciences of Xishuangbanna Dai Autonomous Prefecture | Part of Yunnan Province |
| 20      | Nanning Station of Bast Fiber Crops | Guangxi Academy of Agricultural Sciences | Guangxi |

Although several supportive policies have been proposed or implemented in the five provinces, such as legislation, farm subsidies, action plans and trade association organizing, the majority of hemp businesses are small and lack core competitiveness. For example, the political barrier seems to be the major limiting factor that involves benefit from the CBD industry in Yunnan. The comparative benefit would decline while the barrier is eliminated in north China, such as Heilongjiang and Jilin where a higher level of agricultural mechanization exists. The high-quality growth of hemp fiber and seed industries is also predicted to be slowed due to the excessive competition among regions. Therefore, cooperation among governments and public sectors is encouraged for avoiding excessive competition and enhancing synergistic effects.

5.3. Development Strategy for the Developing Hemp Industry of Each Province

Under the overall framework of the industry in China, regional development strategies are still necessary based on the existing strengths and weaknesses. Hereafter, we tried to propose the countermeasure of each province based on the above backgrounds and SWOT analysis.
5.3.1. ST Strategy in Yunnan

The export of Yunnan’s CBD raw materials is highly threatened in the wake of global legalization and enhancing the supply capacity of industrial hemp. However, the fairly complete system of industry has been shaped in the province. Thus, Yunnan had opportunities in competing CBD markets and seeking new markets in kinds of cannabinoids with diverse bioactivity [43]. As the leader in the cannabinoid production field, Yunnan should take advantage of the current favorable situation in policy regulation and integrate the resources of scientific innovation and industrial clusters to the cost of the application of active substances and explore unique products for human health.

5.3.2. SO Strategy in Shanxi

The most outstanding advantage in Shanxi is that the hemp seed and fiber industries are aligned in the province and have large demand in the domestic market. As the province has formed a relatively complete industrial system, an SO strategy is preferred. For those diverse industries that are challenged by multi-directional competition, Shanxi should highly pay attention to optimization of the funds allocation. Breeding multi-purpose hemp varieties with excellent seed and fiber yield is prioritized in the agriculture sector.

5.3.3. WO Strategy in Heilongjiang

Heilongjiang is the main provider of hemp fibers in China at present. However, fewer profits are gained in the textile industry chain lacking of high-value applications of raw fibers and yarns. Regarding the novel high-density cultivation model of hemp in the province based on the unique climate and environment condition, Heilongjiang is suggested to form a flax-allied-industry, that is similar cultivation, retting, extraction and same processing techniques and equipment as flax but less cost and more profit. To overcome the technical bottleneck of rain and dew retting, innovative and standardized ways by combining the application of biological and chemical additives are needed.

5.3.4. ST Strategy in Inner Mongolia

The hemp industry in Inner Mongolia is highlighted by the large land area and efficient cropping system. Hence, Inner Mongolia is suggested to promoting the production of hemp seed with the wheat/hemp intercropping system. While expanding the planting area, the production tends to be affected by bird damage and high seed shattering ratio. Therefore, researches on hempseed holding and bird control are strongly recommended.

5.3.5. SO Strategy in Jilin

Depending on the advantages of the existing industrial scale of the Northeast Hosiery Industry, a production base of standardized raw materials should be established, which promotes the layout of the whole industrial chain of industrial hemp. Gradually, a characteristic industrial cluster should be formed to improve competitiveness in the textile market. Exploring high-valued textile applications of hemp fiber are recommended in Jilin.

6. Conclusions

Hemp provides unique agricultural, recreational, medicinal and industrial products for societies and presents highly social interests in both scientific research and industrial utilization. Comprehensive utilization of hemp biomass becomes a main trend that brings functional overlapping and homogeneous competition among regions. Given the situation of ongoing regional legislation, underdeveloped pharmaceutical market and starting up scientific and technological research, cross-regional cooperation with synergistic development strategies is urgently needed for a sustainable hemp industry. As the largest producer with $6.54 \times 10^4$ ha of hemp cultivation, the tendency of China will impact the global hemp industry profoundly and therefore it is important to discuss the development strategies in China.
In the present study, a national wide survey and a SWOT analysis were performed with five major production provinces in China, including Yunnan, Heilongjiang, Shanxi, Inner Mongolia and Jilin province. Legislation, distribution, yield and utilization status and their effects were discussed for profiling the economic geographic feature of the hemp industry in China. The hemp industry was characterized by the high heterogeneous spatial distribution and industrial diversity. However, it was challenged by lacking regional development strategies, the driving force from innovation, the capacity of global competition and convergence in economic growth. Based on the SWOT analysis, detailed topics for formulating national strategies, enhancing global competition, promoting science and technology innovation, and public cooperation were proposed. Particularly, specific advancements needed to improve global competition of hemp industry in agricultural sector were provided including improving nutritional and functional components in raw materials, decreasing yield gap between China and advanced countries, reducing labor cost, expanding large-scale planting and rational use of natural resources.

**Supplementary Materials:** The following are available online at [https://www.mdpi.com/article/10.3390/su13116419/s1](https://www.mdpi.com/article/10.3390/su13116419/s1), File S1: Major farming concerns for industrial hemp cultivation in China, File S2: National standards of hemp in China.

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