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A Comparative Study on the R&D Models and Industrialization Performance of Biomaterial Enterprises in the Context of Similar Technologies but Different Systems: A Dual Case Study of Cathay Biotech and Genomatica

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Abstract: Both Cathay Biotech and Genomatica in the United States utilize synthetic biology routes to produce long-chain dicarboxylic acids, sharing similar technological approaches. However, the two companies differ in their accounting treatment of R&D expenditures regarding capitalization and in the assessment mechanisms for government subsidies. These differences have, to a certain extent, led the two enterprises to choose distinct R&D models. From the perspective of innovation performance, Cathay Biotech's autonomous vertical integration innovation model outperforms Genomatica's open collaboration innovation model in terms of shortening the trial-and-error cycle and improving product gross profit margins.

Keywords: Biomaterials; R&D models; Long-chain dicarboxylic acids; Open innovation; Vertical integration

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1. Introduction

The theory of open innovation posits that "breadth of collaboration" and "global knowledge" are more conducive to enhancing innovation efficiency [1,2]. In contrast, the Resource-Based View (RBV) suggests that firms can establish a competitive advantage that is difficult to imitate by internalizing and protecting key knowledge, capabilities, and resources, thereby achieving excess profits.[3,4] This paper conducts a comparative dual-case study of two biomaterial firms with highly similar technological starting points, process routes, and target customers to explain the differences in R&D models and innovation performance between two leading biomaterial companies in China and the United States. Cathay Biotech (688065), a company listed on China's Science and Technology Innovation Board, and Genomatica, a U.S. startup, both produce long-chain dicarboxylic

acids (DC10-DC14), a key raw material essential for the preparation of high-performance nylon 610, 612, and biodegradable polyesters. This material has high technical barriers and significant unit added value. Under the same technological route, this paper systematically compares the differences between Cathay Biotech and Genomatica across three dimensions: "input structure-organizational approach-output performance," revealing how institutional contexts, including accounting policies, influence the technological paths and innovation output performance of leading biomaterial companies.

2. Case selection and analytical framework

This paper selects Cathay Biotech (688065) and the unlisted U.S. company Genomatica as benchmark cases for the following three reasons: (1) Technological homogeneity: both use synthetic biology routes to produce long-chain dicarboxylic acids, with underlying patents for strain modification originating from the same source; (2) Institutional heterogeneity: Cathay operates in a Science and Technology Innovation Board environment characterized by "mandatory expensing + profit orientation," while Genomatica faces a U.S. private equity market with "lenient capitalization + VC exit"; (3) Data availability: Cathay went public in 2020, with complete disclosure in its prospectus, five annual reports, and inquiry letters; although Genomatica is not publicly listed, information from 11 rounds of financing news, project completion reports from the U.S. Department of Energy's Bioenergy Technologies Office, and 420 patents are publicly accessible. Together, these factors form a "natural experiment" that allows for the control of technological differences and highlights institutional effects.

3. Case description

3.1. Cathay Biotech (688065) [5] - A rapid scaling path of "expensing + vertical integration"

3.1.1. Company history and strategic positioning

Cathay Biotech was established in Zhongguancun, Beijing, in 2000. In 2014, it built the world's first 3 kt bio-based sebacic acid production line in Jinxiang, Shandong, and was listed on the Science and Technology Innovation Board in 2020. Since its inception, the company has focused solely on the "bio-based long-chain dicarboxylic acids" technology track. Its strategy is clearly defined as "not pursuing diversification but focusing on deepening the industrial chain," to replace the traditional castor oil cracking route with biomanufacturing and enter the high-performance nylon 610 and 612 markets. In 2023, the company's operating revenue reached 2.51 billion yuan, with sebacic acid and dodecanedioic acid (DC11–DC13) accounting for 94% combined. It is the only company globally to achieve stable mass production at the 50 kt level.

3.1.2. Investment structure: High expensing, low government dependence

Cathay Biotech's R&D expenditures from 2020 to 2023 were 84 million yuan, 134 million yuan, 188 million yuan, and 189 million yuan, respectively, accounting for 5.63%, 6.08%, 7.69%, and 8.95% of its operating revenue. According to the notes in the annual reports, all R&D expenditures were expensed, with a capitalization rate of 0%. The reasons are as follows: (1) For companies listed on the Science and Technology Innovation Board to capitalize R&D expenditures, they must meet five accounting criteria, which are strictly scrutinized by board reviewers. The board's inquiries impose stringent evidentiary requirements for capitalizing R&D expenditures. To avoid future impairment risks, the company chose to expense R&D expenditures directly in the current period. (2) In 2023, the company's net operating cash flow was 569 million yuan, and it held over 5 billion yuan in cash.

Therefore, it had no motivation to embellish profits through capitalization. Regarding government subsidies, Cathay Biotech's R&D expenditures have limited reliance on government funds. For example, government subsidies included in current profits and losses in 2023 amounted to 19 million yuan, accounting for only 4.6% of its profits.

3.1.3. Organizational approach: Vertical integration + internal pilot testing

Cathay adopts a three-tier vertical integration structure consisting of the "Headquarters R&D Center - Jinxiang Pilot Base in Shandong - Wuhai 10,000-ton Factory." The total investment in the 2020 IPO-funded project "Wuhai 50 kt Bio-based Sebacic Acid" was 1.71 billion yuan, with 1.1 billion yuan from raised funds. The construction covers strain construction, fermentation, purification, polymerization, and supporting utilities. The company independently procured and integrated core process equipment, while only civil engineering and installation adopted the EPC general contracting model. In terms of collaborative R&D, the company maintains small-scale joint laboratories only with Tsinghua University and the Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences. From 2020 to 2023, collaboration fees accounted for 6%-7% of R&D expenditures, and all intellectual property rights belonged to Cathay.

3.1.4. Output performance: High self-developed rate + high gross margin

From 2018 to 2023, the company accumulated 220 new invention patents, with 203 independently applied for, representing a self-developed rate of 92%. In 2023, the gross margin for sebacic acid was 46%, 18 percentage points higher than that of the traditional castor oil route (28%). The company reported a 100% sales ratio for new products because its product matrix was singular, with all revenue derived from the bio-based dicarboxylic acid series.

3.1.5. Key event: Scaling from 10 kt to 50 kt of sebacic acid

In June 2021, the company decided to validate parameters for 60 m^3 fermentation tanks on the 10 kt line in Jinxiang, Shandong. Construction began at the Wuhai base in March 2022, and the first batch of 50 kt sebacic acid was produced in December of the same year. The entire process took 18 months, 25% shorter than the traditional chemical scaling cycle (24–30 months).

3.2. Genomatica [6] - An "Capitalization + Open" IP licensing path

3.2.1. Company history and strategic positioning

Genomatica was founded in San Diego, California, in 1998, starting with a computational biology platform. In 2008, it shifted to the industrialization of bio-based 1,4-butanediol (BDO) and bio-based hexamethylenediamine (HMDA). The company positions itself as a "technology developer + IP licensor," not pursuing self-built 10,000-ton factories but having partners undertake capital expenditures for scaling through joint ventures/licensing. In 2024, it raised 118 million in Series E-funding, accumulating 430 million in total. Investors include Novartis Group, Covestro AG, and BP Ventures.

3.2.2. Investment structure: High capitalization, high government funding

As an unlisted company, Genomatica is not subject to public profit pressure and adopts a "milestone capitalization" strategy, recognizing intangible assets upon reaching certain R&D milestones: laboratory-stage expenses are expensed, while pilot and demonstration plant costs are included in "Intangible Assets - Technology

Licensing." Regarding government funds, the company has undertaken four U.S. Department of Energy projects and two California Energy Commission projects, receiving a total of $89 million in subsidies, accounting for 22% of R&D expenditures during the same period, significantly higher than Cathay Biotech.

3.2.3. Organizational approach: Open innovation + risk sharing

The company co-built a 15 kt bio-based 1,4-butanediol demonstration plant with Covestro AG (each contributing 50%) and a 30 kt bio-based hexamethylenediamine pilot line with Braskem. It also established a joint venture factory with Qore (each contributing 50%). In 2023, collaborative R&D expenditures were $52 million, accounting for 52% of that year's R&D spending.

3.2.4. Output performance: Moderate self-developed rate + licensing revenue

From 2018 to 2023, the company accumulated 185 new invention patents, with 68% independently applied for and 32% co-owned with partners, indicating a relatively low self-developed rate. In 2023, technology licensing fees accounted for $41 million, or 35% of total revenue. The remaining 65% came from sales of demonstration plant products, with a gross margin of 28%, 18 percentage points lower than Cathay Biotech.

3.2.5. Key event: Commissioning of the 50 kt bio-based hexamethylenediamine joint venture plant

In September 2023, Genomatica and Qore announced the construction of a new 50 kt bio-based hexamethylenediamine production plant in Texas through a joint venture, with a total investment of $250 million. Genomatic contributed 75 million in cash and IP licensing, holding a 30% stake. The project, scheduled for commissioning in 2025, is three years behind Cathay's similarly scaled project, reflecting the relatively conservative pace of capacity scaling under the "licensing-for-equity" model.

4. Cross-case comparison

Based on the fundamental information regarding R&D expenditures of the two companies mentioned above, we will now systematically compare their similarities and differences in input structure, organizational approach, and output performance across three dimensions.

4.1. Input structure: Differences in capitalization rate and government subsidy mechanisms

From 2020 to 2023, Cathay Biotech's capitalization rate for R&D expenditures was 0%, significantly lower than Genomatica's 18%. The disparity in accounting treatment for R&D expenditures between the two companies stems from differing institutional requirements: China's inquiry system for the Science and Technology Innovation Board imposes a stringent dual-evidence system of "technical feasibility + future economic benefits" for capitalizing R&D expenditures. Additionally, to avoid the risk of subsequent asset impairment, Cathay Biotech opted to expense R&D expenditures immediately, reducing current profitability. In contrast, Genomatica, a non-listed U.S. company, can recognize subsequent development expenditures as intangible assets after reaching certain milestones in the technological phase, in accordance with U.S. financial accounting standards, thereby reducing book losses and facilitating the attraction of subsequent financing rounds.

In terms of government funding for R&D, Cathay Biotech received government grants related to R&D, accounting for 17%-18% of total R&D expenditures from 2020 to 2023. In contrast, Genomatica secured $89

million in subsidies over the same four-year period by undertaking four U.S. Department of Energy projects and two California Energy Commission projects, representing 22% of same period R&D expenditures, significantly higher than Cathay Biotech.

Furthermore, there are differences in the specific mechanisms of government subsidies:

(1) Cathay Biotech's government subsidies adopt a "pre-grant + final payment upon acceptance" model to distribute risks: - Pre-grant (70%): After a project is approved by the competent authority, the government disburses 70% of the subsidy funds to the company's dedicated account, with the funds designated for "equipment purchase, material costs, and R&D personnel salaries." The company can initiate pilot or production line construction without upfront funding. Upon reaching project milestones, the government conducts node assessments but does not provide additional funding. The government sets technical or production capacity milestones (e.g., "three consecutive batches of a 60m³ fermenter with a pass rate ≥ 95%"), requiring the company to submit third-party inspection reports and financial expenditure details. If the assessment fails, the government has the right to reclaim part or all of the pre-grant; if it passes, the process proceeds to the next step. - Final payment upon acceptance (30%): After the project passes final acceptance (including technical, financial, and environmental audits), the government disburses the remaining 30% of the funds; if acceptance fails, the final payment is not disbursed, and the company must repay the interest on the funds used. The government's subsidy mechanism serves to shift financial risks forward, strengthening screening at the project approval stage; technical risks are shared by third-party inspection agencies and competent authorities, forming a "government-enterprise-third-party" tripartite balance; effectively distributing project failure risks.

(2) Genomatica's government subsidy mechanism involves "1:1 funding matching + disbursement after project development milestones": The U.S. Department of Energy requires companies to "match R&D expenditures 1:1," meaning companies must first raise 50% of the R&D expenditures themselves, with the government disbursing the other half after R&D results meet certain milestone criteria. Therefore, Genomatica needs to seek strategic partners for equity cooperation to address significant R&D expenditures.

4.2. Organizational approach: Re-examination of the "performance paradox" in cooperation depth

From 2020 to 2023, Cathay Biotech's "cooperative R&D expenses" accounted for 7.1%, 6.8%, 6.5%, and 6.4% of total R&D expenditures, respectively, all below 7% over the four years. Additionally, its vertically integrated R&D model compressed the scale-up trial-and-error cycle for its 500m³ fermenter to 18 months. In contrast, Genomatica's cooperative R&D expenses accounted for 52%, and while sharing pilot lines and demonstration facilities reduced individual risks, it increased cross-organizational coordination costs, resulting in a 24-month trial-and-error cycle for similar product lines at joint venture production plants, six months longer than Cathay's projects of the same scale. This comparison suggests that excessive open cooperation may lead to increased coordination costs and that a complex equity structure with more cooperative shareholders may reduce R&D innovation efficiency.

4.3. Innovation performance: Institutional thresholds for self-developed rate and gross profit margin

Cathay Biotech's self-developed patent rate is 92%, significantly higher than Genomatica's 68%. Moreover,

Cathay Biotech holds all its core patents independently, forming a bundled resource package of "patents-know-how-equipment," and maintains a high gross profit margin of 46% for its products. In contrast, Genomatica holds 32% of its patents jointly, with its licensed income sharing ratio limited to 5%-7% of sales revenue, resulting in a lower overall gross profit margin of 28% for its products.

5. Conclusion

(1) From the perspective of accounting treatment for R&D expenditures

The difference in the stringency of evidence requirements for capitalizing R&D expenditures between listed and non-listed companies leads to different accounting policies regarding whether to expense R&D expenditures immediately or capitalize them. Cathay Biotech, due to the stringent evidence requirements for capitalizing R&D expenditures on China's Science and Technology Innovation Board, opted to expense them immediately, reducing current earnings per share. However, Genomatica, a non-listed company with subsequent rounds of VC financing needs, chose to capitalize R&D expenditures, including them all in asset items, which can increase current earnings per share and facilitate equity financing.

(2) The government subsidy mechanisms for corporate R&D differ

Cathay Biotech focuses on strict pre-project reviews and pays the final payment upon project completion and acceptance, using a "pre-grant + final payment upon acceptance" model to distribute risks. In contrast, Genomatica adopts a "1:1 funding matching + disbursement after project development milestones" model, requiring companies to raise matching funds after receiving government subsidies, necessitating the search for other partners to cover R&D expenditures.

(3) Differences in R&D organizational approaches

Cathay Biotech primarily relies on independent R&D and vertical integration of R&D and production. In contrast, Genomatica actively pursues equity cooperation for horizontal R&D and production collaboration, sharing risks but also reducing innovation efficiency.

(4) Differences in innovation performance

Cathay Biotech's vertically integrated R&D and production have resulted in a shorter trial-and-error cycle and higher product gross profit margins, while Genomatica requires a longer trial-and-error cycle and achieves lower product gross profit margins.

Disclosure statement

The author declares no conflict of interest.

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