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Strategic Choices for Energy Enterprise Survival and Development: An Analysis of Market Power, Innovation Strategy, and Sustainable Development of Major Multinational Oil Companies

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Abstract: With the economic recession and the deterioration of the ecological environment becoming more and more prominent in the world, the sustainable operation of enterprises is facing the most difficult choice in history. For each responsible enterprise, it is crucial to choose the market power expansive strategy that can improve the realistic viability or the technological innovation strategy that can improve the future development potential. This is of great significance to reduce the negative external effects of the corporate social environment and ensure their sustainable development. In this paper, we select the data of 18 large listed petrochemical companies from 2003 to 2018 as samples and construct a linear regression model for empirical analysis. Meanwhile, we put forward more practical business management strategies for the sustainable development of petrochemical enterprises in developing countries in further research.

Keywords: market power expansive strategy; technological innovation strategy; sustainable development of enterprises; firm sustainable total factor productivity; negative data in DEA

1. Introduction

Since the Second World War, human beings have long suffered from global population expansion, energy crisis, excessive resource consumption, serious environmental pollution, climate change, sharp decline of biodiversity, poverty, disease, global security, and other problems, which have aroused the worries of many scientists and politicians [1]. Therefore, the ecological environment and environmental protection have become fields of great concern to governments and people of all countries, which determine the policies of social and economic development and the goals of international cooperation of all countries, especially developed countries [2]. However, a conflict between Russia and Ukraine has brought into sharp focus a long-standing fact of global recession, creating a huge wave of public opinion around environmental protection and economic development, and the withdrawal of low-cost fossil fuels. "Realistic survival" and "future development" have become a conflict issue that is difficult to ignore in front of people all over the world. This is the most serious challenge faced by the theory of sustainable development, the theoretical weapon of environmental protection proponents, since its establishment. This has triggered a wide range of thinking about "whether it is feasible to harm the rights and interests of the current generation to ensure intergenerational equity."[3] The above discussion exists in various fields, especially in the area of corporate sustainability. Moreover, the trend of environmental protection derived from the theory of sustainable development has given enterprises too many expectations of social responsibility beyond their tasks, such as boosting the economy, saving resources, and protecting the environment [4]. Considering the conflict between the goals of "short-term interests" and "long-term development" existing in the enterprise itself, the enterprise also faces the difficult problem in the process of sustainable social and economic development -- which is more important, "actual survival" or "future development"?

Therefore, the most obvious reflection is that enterprise management is faced with the dilemma of choosing between the "technological innovation strategy" that protects the environment, improves productivity or resource utilization, and ensures absolute competitiveness in the future, and the "market power expansion strategy" that expands market influence, occupies the absolute market advantage, and obtains the current market survival. Especially in the petrochemical industry, which is at the center of the conflict over the storage and waste of fossil fuels, this dilemma of strategic choice is prominent.

Existing studies focus on effective market behavior, which can obtain visible financial and operational performance and achieve corporate profit goals [5]. Some studies believe that enterprises should put quality improvement and technological innovation in an important position to maintain long-term competitive advantages when productivity reaches a certain level[6]. Some studies emphasize that enterprise behavior must follow the principle of sustainable development, not only paying attention to "actual survival", but also considering "future development". However, in the process of specific management practice, what kind of market behavior can not only achieve the profit target of the enterprise but also take into account sustainable development in the future? What kind of technological innovation behaviors can not only obtain the competitive advantage of future possibilities but also ensure the market survival in the current period? What kind of corporate behavior is in line with the principles of sustainable development? There is less relevant research literature on these issues. In particular, as mentioned above, when enterprises are faced with the conflict between "technological innovation strategy" and "market power expansion strategy," how to choose a choice that is more conducive to the sustainable development of enterprises has not been involved in the literature. To solve these problems, this study first considers the feasibility of using the total factor productivity of enterprise sustainable development, namely the total factor productivity index that includes the basic factors of sustainable development, to approximate the degree of sustainable development based on discussing the existing indicators of enterprise sustainable development. Then, for enterprises facing environmental protection and resource constraints that need to make strategic choices, especially in the petrochemical industry, most of them are mature and large listed companies with certain productivity, and their sample data may have a large number of negative values, so it is not possible to use ordinary DEA method to measure their total factor productivity. A new measurement model of common and group frontier is constructed. Finally, we use the historical data of large multinational oil companies to test the impact of technological innovation and market power expansive strategies on the sustainable development of petrochemical enterprises. Therefore, it provides technical support and guidance for enterprises facing strategic choice dilemmas, especially for petrochemical enterprises facing greater environmental protection pressure and financing constraints in the current period.

The paper unfolds as follows. Section 2 presents the research hypothesis through theoretical analysis. Section 3 constructs a new meta-Malmquist index by basing it on the negatively constrained RDM model. Section 4 describes the research methodology and data. Section 5 uses the empirical analysis method to test the impact of technological innovation and market power expansive strategy on the sustainable development of enterprises. Section 6 makes a comparative analysis with other scholars' research. Section 7 summarizes the main research conclusions and provides relevant policy recommendations.

2. Theoretical analysis and research hypothesis

According to the sustainable development theory, the evaluation index for sustainable development of enterprise needs further research and discussion. In the 1960s, the book, called "Silent Spring", proposed the idea of harmonious coexistence between humans and other creatures, and then it was defined by the World Commission on Environment and Development (WCED) in 1987. Subsequently, a series of international cooperation agendas was set out. Researchers concur that the theory is based on the principle of sustainable equity, encompassing intergenerational equity and intra-generational equity [7]. The theory of corporate sustainable development cannot deviate from this core principle, resulting in two distinct evaluation perspectives: the resource and environment relations perspective emphasizing intergenerational equity, and the perspective of corporate sustainable development focusing on intra-generational equity. The ESG (Environmental, Social, and Governance) evaluation is the most widely recognized method from the intergenerational equity perspective [4]. On the other hand, the perspective of enterprise's sustainable development, specifically the intra-generational equity perspective, lacks a universally acknowledged evaluation method. However, the assessment of an enterprise's sustainable competitiveness, developed in conjunction with Porter's competitive strategy theory, and the enterprise performance evaluation, resulting from the enterprise financial system, have garnered relatively wide recognition. These two evaluation perspectives have evolved independently over time. Both of them are supported by a substantial body of literature.

Our paper posits that the relationship between the two evaluation perspectives is not naturally independent, but rather unified, and for ensuring comparability of evaluation and feasibility of enterprise practice, both of them should be unified. Firstly, the sustainable development of enterprises is a necessary condition for the sustainable development of society. Promoting the sustainable development of the social economy requires enhancing the internal potential of enterprises and creating a conducive environment for their sustainable development. Secondly, the realization of resource-environment relationship goals influences the achievement of enterprises' own sustainable development goals. High levels of ESG performance facilitate a firm's recognition and regulation by stakeholders, and the altruistic signal transmitted attracts investment and financing opportunities [8]. Firm innovation theory emphasizes the importance of considering the values and expectations of corporate stakeholders in technological and market-oriented business model innovation. Finally, achieving resource and environment relationship goals and the sustainable development goals of enterprises is contingent on the survival of enterprises. Sustainable development of enterprises hinges on avoiding bankruptcy caused by factors such as declining profits, erroneous investment decisions, and human resource exhaustion. Enterprise survival is a prerequisite for sustainable development and the advancement of the social economy.

Basis of enterprise survival. According to the classical economic theory, the enterprise is a production function that pursues profit maximization; According to the theory of new institutional economics, enterprises are organizations that save transaction costs instead of market mechanism. Some scholars believe that the enterprise is a special contract between human capital and non-human capital [2]. From this point of view, the supporting factors for the survival of enterprises should include at least three aspects: the degree of cost saving, the adaptability of product market demand, and the sustainability of human capital.

Degree of enterprise cost saving. According to the two evaluation perspectives of enterprise sustainable development indicators, firstly, enterprises participate in environmental protection to maintain good public relations and thus save transaction costs, which is the support for the survival and development of enterprises. Secondly, to save their production costs and achieve the fundamental goal of cost minimization, that is, profit maximization, enterprises must save resources, which is the basic sustainable development supporting factor based on the survival basis and fundamental goal of enterprises. At present, most evaluation indicators from the two perspectives directly or indirectly consider this supporting factor in essence.

Adaptability of product market demand. In the information age, rapid changes in the market environment due to intense competition make it challenging to assess enterprise sustainable development solely based on size [9,10]. Additionally, different industry demand characteristics correspond to different optimal firm sizes. Therefore, understanding market demand characteristics and developing market adaptability to swiftly respond to consumer preferences can better indicate an enterprise's sustainable development ability [11]. There are two evaluation perspectives for assessing enterprise sustainable development: the resource and environment relationship perspective, and the enterprise's sustainable perspective, which evaluates its sustainable development ability based on market share and operating income.

Persistence of human capital. As the basic condition of enterprise operation, human capital includes not only the core entrepreneurs or enterprise decision-makers but also the core management and technical personnel of the enterprise [12].

Due to the large weight of environmental and social factors in the existing ESG indicators, they do not directly reflect the two aspects of enterprise cost savings and human capital sustainability. Existing enterprise competitiveness and growth evaluation indicators, although from the output point of view reflect the three major support elements of enterprise survival, but only the outcome evaluation, the lack of process evaluation [13,14]. Therefore, this paper argues that total factor productivity, which can be measured by the DEA method of multiple inputs and multiple outputs without the need to set the production function, can take into account the three major support elements of enterprise sustainable development by controlling the selection of its input and output indicators. Moreover, by adopting the dynamic Malmquist measurement, it can take into account both process and result evaluation. Based on the above analysis, this paper puts forward the following hypothesis.

H1: *The higher the sustainable total factor productivity of the enterprise that includes the examination of the three major supporting elements of enterprise sustainable development, the stronger the enterprise's sustainable development ability.*

According to the theory of industrial organization, market power is the ability of enterprises to control the market price or monopolize the market [15]. It mainly consists of cost advantage and demand advantage, and the factors affecting both of these advantages affect market power. The first is the way to gain cost or demand advantage by improving the irreplaceability of products or the comparative competitive advantage of firms, which is short-term and socio-economically harmless. The second is to obtain cost or demand advantages through government support and resource monopoly, which is long-term and harmful to the social economy [16]. Therefore, to achieve sustainable development, firms should adopt the first approach to market power expansion to reduce the negative externalities of firms. This paper discusses the market power of enterprises acquired through the first way of influence.

Enterprises can reduce their production and transaction costs by changing product structure, adjusting market layout, and optimizing supply channels to obtain cost advantages [17]. Enterprises can obtain demand advantages through market segmentation, product design, and product sales model innovation [18]. These market behaviors to obtain advantages will further promote the sustainable development of enterprises so that labor productivity increases, the sustainability of human capital is enhanced, and the enterprise's sustainable development capability is promoted. Based on the above analysis, this paper puts forward the following hypothesis.

H2: *Market power expansion strategies can promote sustainable total factor productivity improvement and enhance the sustainability of enterprises.*

Innovation is a long-cycle, high-cost, and high-risk economic activity. Due to the internal principal-agent problem of the "separation of powers" management mechanism, enterprises lack incentives for innovation projects [19]. In addition, due to the principal-agent conflict between investors and internal personnel, enterprises face constraints on the investment of innovation funds [20]. Firms may lack the willingness to invest in innovation due to these two principal-agent problems. However, innovation can bring many benefits to enterprises. Enterprise innovation can reduce the carbon emissions of enterprises to achieve better environmental performance [21], which can develop safer and more reliable products to improve consumer trust and enterprise reputation [22], can improve the quality of enterprise products, reduce operating costs, and improve market competitiveness [23,24]. Therefore, innovation is an important strategic decision for enterprises. Based on the above analysis, this paper puts forward the following hypothesis.

H3: *Technological innovation strategy can promote sustainable total factor productivity improvement and enhance the sustainable development ability of enterprises.*

Enterprises can achieve sustainability goals through some strategies, for example, technological innovation, market power expansion, and so on [25]. Compared with the market power expansive strategy, the technological innovation strategy can be more sustainable to enhance the three key elements of sustainability, i.e., cost savings, adaptability to market demand, and sustainability of human capital. In particular, in the case that both strategies have unknown problems of input costs, adaptability to product market demand, and personnel incentives, the strategy that positively improves sustainability is more consistent with the principle of Pareto optimality. Based on the above analysis, this paper puts forward the following hypothesis.

H4: *When facing the choice between market power expansion and technological innovation strategy, the choice of technological innovation strategy is more able to promote the sustainable total factor productivity improvement of the enterprise, and the enterprise's sustainable development ability is stronger.*

3. The RDM for computing efficiency measures

The common measurement methods of TFP include parameter methods, such as the stochastic frontier method, etc., and nonparametric methods, such as Data Envelopment Analysis (DEA). However, the stochastic frontier analysis is only suitable for the measurement of output per unit with multiple inputs and must set the specific form of the production function, which leads to errors in the results. Furthermore, the index method has strict assumptions such as constant marginal productivity and safe substitution of capital and labor. Therefore, they are not suitable for the measurement situation in this paper. This paper chooses the Malmquist index, which is suitable for the dynamic investigation of multi-input and multi-output, to conduct the process and outcome common evaluation on the three basic supporting elements of enterprise sustainable development [26].

Moreover, considering that the sample data of the petrochemical industry may have a large number of negative values. Therefore, this paper chooses the negative value-constrained RDM model based on DEA and modifies it to fit the measure in this paper.

3.1. The RDM Model

In the DEA method, the common method of processing the negative value is based on its characteristics, namely unit invariance and transformation invariance, to proper preprocessing. These include the method of fixed value direction vector, the conversion of input-output indicators to positive by adding the negative value of the positive vector, and the average input and output vector [27,28]. However, these methods all possess certain limitations. The selection of a fixed value direction vector is subjective and speculative. In contrast, adding a positive vector or direct average can lead to data deviation from their actual values.

Therefore, following the work of [29], we proposed applying the evaluation concept of directional distance function to enhance the DEA method. Consider a set of unit j (j=1, …, n) and a vector x_{ij}^t reflecting m inputs consumed for producing a vector of s outputs y_{ij}^t in time period t. Consider the technology of time period t as $\boldsymbol{T}^t=\{(\boldsymbol{x}^t,\boldsymbol{y}^t),\ \boldsymbol{x}^t can\ produce\ \boldsymbol{y}^t\}$. Following [29], we consider (g_x, g_y) as the directional vector and results in the directional distance function being generally defined as:

$$\overrightarrow{D^t}\left(\boldsymbol{x}_k^t,\boldsymbol{y}_k^t,\boldsymbol{g}_x,\boldsymbol{g}_y\right)=sup\left\{\beta|\boldsymbol{x}_k^t-\beta\boldsymbol{g}_x,\boldsymbol{y}_k^t+\beta\boldsymbol{g}_y\right\} \tag{1}$$

The directional distance function can be used with any directional vector. The above problems can be solved through linear programming using the model in (2):

$$\begin{cases} max\,\beta_0 \\ s.t.\sum_{j=1}^{n}\lambda_j y_{rj}^t \ge y_{r0}^t+\beta_0 g_{yr}^t \\ \sum_{j=1}^{n}\lambda_j x_{ij}^t \ge x_0^t-\beta_0 g_{xi}^t \\ \lambda_j,\beta_0,g_{xi}^t,g_{yr}^t \ge 0 \end{cases} \quad (r=1,2,\cdots,s;i=1,2,\cdots,m) \tag{2}$$

In model (2), the condition for satisfying the direction vector is that its variable values should be greater than 0. Therefore, consider an ideal point as $I=\left(max_J\, y_j^t, r=1,2,\cdots,s; min_J\, x_j^t, i=1,2,\cdots,m\right)$, we can define the directional victors P_{r0} and P_{i0} in (3), which we define as the range of possible improvement of unit o.

$$\begin{cases} p_{r0} = max_J\left(y_{rj}^t\right) - y_{r0}^t \quad r = 1,2,\cdots,s \\ p_{i0} = x_0^t - min_J\left(x_{ij}^t\right) \quad i = 1,2,\cdots,m \end{cases} \tag{3}$$

Thus, we can obtain the directional distance function in (4):

$$\overrightarrow{DP^t}\left(\boldsymbol{x}_k^t, \boldsymbol{y}_k^t, \boldsymbol{P}_{x_k^t}, \boldsymbol{P}_{y_k^t}\right) = sup\left\{\beta \middle| \boldsymbol{x}_k^t - \beta \boldsymbol{P}_x, \boldsymbol{y}_k^t + \beta \boldsymbol{P}_y\right\} \tag{4}$$

Based on the notion of the range of possible improvement in (2) and (3), the linear programming of the model is followed as:

$$\begin{cases} max\, \beta_0 \\ s.t. \sum_{j=1}^{n} \lambda_j y_{rj}^t \ge y_{r0}^t + \beta_0 p_{r0}^t \\ \sum_{j=1}^{n} \lambda_j x_{ij}^t \ge x_0^t - \beta_0 p_{i0}^t \qquad (r = 1,2,\cdots,s; i = 1,2,\cdots,m) \\ e\lambda = 1 \\ \lambda_j, \beta_0, p_{xi}^t, p_{yr}^t \ge 0 \end{cases} \tag{5}$$

We can obtain an inefficiency measure equal to $\overrightarrow{DP^t}\left(\boldsymbol{x}_k^t, \boldsymbol{y}_k^t, \boldsymbol{0}, \boldsymbol{P}_{y_k^t}\right) = \beta^* = y^{t*} - y_{r0}^t / p_{r0}^t$, which is provided by the optimal solution to model (5). Moreover, we define $\overrightarrow{RDM^t}\left(\boldsymbol{x}_k^t, \boldsymbol{y}_k^t, \boldsymbol{0}, \boldsymbol{P}_{y_k^t}\right) = 1 - \overrightarrow{DP^t}\left(\boldsymbol{x}_k^t, \boldsymbol{y}_k^t, \boldsymbol{0}, \boldsymbol{P}_{y_k^t}\right) = 1 - \beta^*$ as the RDM output 'meta-efficiency' of unit j in period t. Note that we have $1 - \beta^* = \left(max\left(y_{rj}^t\right) - y^{t*}\right) / \left(max\left(y_{rj}^t\right) - y_{r0}^t\right)$ for each output r.

3.2. Meta-Malmquist indices

As previously mentioned, we will employ a meta-frontier, which comprises the pooled data of a panel covering many time periods and which we refer to as the meta-period in order to calculate our index and indicator of productivity change.

Following the work of [29], we let $\overrightarrow{DP^t}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}\right)$ be expressed as $\overrightarrow{DP^{mf}}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right)$ when the meta-frontier is the technology employed to determine the directional distance function of DMU j in period t. The term $\overrightarrow{DP^{mf}}$ indicates the distance function is concerning the meta-frontier and $\boldsymbol{P}_{y_j^t}^{mf}$ denotes the maximum increase in output under the meta-frontier. Thus, we can obtain the ideal point is $I = \left(max_T\, max_J\, y_j^t, r = 1,2,\cdots,s; min_J\, x_j^t, i = 1,2,\cdots,m\right)$.

We define $\overrightarrow{RDM^{mf}}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right) = 1 - \overrightarrow{DP^{mf}}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_k^t}^{mf}\right)$ as the RDM output '*meta-efficiency*' of unit j in period t. Then, $\overrightarrow{RDM^t}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right) = 1 - \overrightarrow{DP^t}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_k^t}^{mf}\right)$ can be the RDM '*within-period-efficiency*' of unit j in period t. Because the within-period efficiencies remain at the same ideal point as meta-efficiencies, which can keep collinearity between the directional distance from the observation point to the target under the meta-frontier and the directional distance from the ideal point under the group frontier to the target value under the meta-frontier. This allows the calculation of various RDM efficiencies.

$$\overrightarrow{RDM^{mf}}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right) = \overrightarrow{RDM^t}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right) \times \boldsymbol{RE}_j^f \tag{6}$$

where $\boldsymbol{RE}_j^f$ is retrieved residually as in (7):

$$\boldsymbol{RE}_j^f = \overrightarrow{RDM^{mf}}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right) \Big/ \overrightarrow{RDM^t}\left(\boldsymbol{x}_j^t, \boldsymbol{y}_j^t, \boldsymbol{0}, \boldsymbol{P}_{y_j^t}^{mf}\right) \tag{7}$$

Using the aforementioned definitions where efficiency measures are computed through the RDM model, a Meta-Malmquist index can be followed as in (8):

$$MM_j^{t,t+1} = \frac{\overrightarrow{RDM}^{mf}\left(\boldsymbol{x}_j^{t+1}, \boldsymbol{y}_j^{t+1}, \boldsymbol{0}, \boldsymbol{P}_{y_j^{t+1}}^{mf}\right)}{\overrightarrow{RDM}^{mf}\left(\boldsymbol{x}_j^{t}, \boldsymbol{y}_j^{t}, \boldsymbol{0}, \boldsymbol{P}_{y_j^{t}}^{mf}\right)} \tag{8}$$

By substituting (8), we can decompose the Meta-Malmquist index as shown in (9):

$$MM_j^{t,t+1} = \frac{\overrightarrow{RDM}^{mf}\left(x_j^{t+1}, y_j^{t+1}, 0, P_{y_j^{t+1}}^{mf}\right)}{\overrightarrow{RDM}^{mf}\left(x_j^{t}, y_j^{t}, 0, P_{y_j^{t}}^{mf}\right)} = \frac{\overrightarrow{RDM}^{t}\left(x_j^{t+1}, y_j^{t+1}, 0, P_{y_j^{t+1}}^{mf}\right)}{\overrightarrow{RDM}^{t}\left(x_j^{t}, y_j^{t}, 0, P_{y_j^{t}}^{mf}\right)} \times \frac{RE_j^{t+1}}{RE_j^{t}} \tag{9}$$

The pure technical efficiency change of unit j from year t to year t + 1 is captured by the first term in equation (9). The second term captures the pure technical progress change between the VRS frontiers of periods t and t + 1 in (9).

3.3 Group-Malmquist indices

To avoid different frontiers in different periods of the model, the Meta-Malmquist index is constructed in the previous section, the global idea is introduced to construct a common Frontier, and the Meta Frontier Malmquist method is used for calculation, effectively avoiding the problem of no solution in RDM. However, there are significant differences in characteristics between the developed countries and the developing countries in the sample groups, and the assumption of the common Frontier may have certain restrictions.

Our sample is composed of around 18 large multinational oil companies that have been ranked among the top 500 in the world in recent years, covering both developed and developing countries. The business scope of the enterprise covers oil, natural gas exploration and development, refined oil refining and sales, and other links. The main data in this paper were from the BvD Osiris Global Public Company Analysis Library and the time horizon was 2009–2018. We selected the listed petroleum companies data from the categories such as Royal Dutch Shel, BP, Exxon Mobil, Total, Chevron, Rosneft, Valero Energy, Lukoil, Petrobras, Eni, Indian Oil, PTT PCL, Oil & Natural Gas, Repsol, ConocoPhillips, Suncor Energy.

To comprehensively evaluate the sustainable production and operation efficiency of enterprises, this paper selects the input index in detail: (1) Total assets, which is used to investigate the capital input and resource allocation of enterprises; (2) Main business cost and various period expenses, which can examine the cost-saving efficiency of internal management of the enterprise; (3) Various expenses, examining the internal management performance of the enterprise; (4) The number of employees, which is used to examine the stable status of labor input. Similarly, the following output indicators are selected in detail: (1) main business income, investigate the adaptability of current product market demand, future development prospects and guarantee degree of the enterprise; (2) Net profit, examining the profitability of the enterprise at the present stage.

4. Research design

Following the work of [30], we select the total factor productivity of the sustainable development of oil enterprises, technical efficiency and technological progress of petroleum enterprises as explained variables, and market power and innovation strategy as independent variables. The model is constructed as follows:

$$\begin{aligned} Y_{it} &= \alpha_0 + \alpha_1 markpow_{it} + \alpha_2 innov_{it} + \alpha_3 ownstr_{it} + \alpha_4 propstr_{it} \\ &+ \alpha_5 assstr_{it} + \alpha_6 liqrat_{it} + \alpha_7 assgrow_{it} + \alpha_8 shock_{it} + \varepsilon_{it} \end{aligned} \tag{1}$$

Where i and t represent enterprise and time respectively; Y examines the sustainable development of total factor productivity, technical efficiency and technological progress of each sample enterprise; $markpow$、$innov$ are market power and innovation strategy, respectively; $ownstr$、$propstr$、$assstr$、$liqrat$、$assgrow$、$shock$ are ownership structure, property structure, asset structure, liquidity ratio, asset growth rate and international financial crisis respectively, where international financial crisis is a dummy variable; ε is the error term.

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Explained variable: The MM model (i.e., Meta-Malmquist's RDM model with the inclusion of a common frontier) and the GM model (Group-Malmquist's RDM model with the inclusion of a grouped frontier) measure the sustainable development of a firm, which is affected by the target market, the competitive environment in which it is located, and the international politics, etc., and will differ. In addition, the Malmquist measure can be decomposed into the catch-up effect and the frontier-shift effect. Therefore, we select total factor productivity (*MI_MM*), technical efficiency (*EC_MM*), technological progress (*TC_MM*) and total factor productivity (*MI_GM*), technical efficiency (*EC_GM*), technological progress (*TC_GM*) of the MM model and the GM model as the explanatory variables respectively.

Explanatory variables: (1) Market power (*markpow*). Market power is used to measure the ability of enterprises to control the market and the competitiveness of their products in the market, which can be measured by the Lerner index[31]. (2) Innovation strategy (*innov*). Innovation strategy is expressed as the strategic decision used to measure enterprises' treatment of innovation. To maintain sustainable development, enterprises need to continuously improve their innovation ability in the increasingly competitive market environment. As a high-risk long-term investment, R&D investment needs to be supported by the company's strategic decision-making level to maintain the consistency of decision-making and the sustainable development of innovation.

Control variables: (1) Shareholding structure (*ownstr*), which refers to the shareholding ratio of the largest shareholder. (2) Property rights structure (*propstr*): the ultimate owner of the property rights of the enterprise is a dummy variable with 0 for state ownership and 1 for others. (3) Asset structure (*assstr*) is used to measure the asset allocation of enterprises, which is measured by (fixed assets + inventory)/total assets regarding [32]. (4) Current ratio (*liqrat*), which measures the ability of an enterprise to use cash for debt repayment and the ratio of current assets to short-term liabilities. (5) Asset growth rate (*assgrow*), which is used to measure the growth of assets and is expressed as (total assets of the current period - total assets of the previous period)/total assets of the previous period. (6) International financial crisis (*shock*) is a dummy variable with a value of 1 for the occurrence of an economic crisis and 0 for the absence of an economic crisis.

The description of variables is shown in Table 1:

Table 1. Summary statistics.

Variable	Mean	St. dev	Min	Max	skewness	kurtosis	JB	Number
MI_MM	1.041	0.460	0.051	2.132	8.617	93.924	96000***	270
EC_MM	1.001	0.050	0.759	1.254	0.568	11.343	797.6***	270
TC_MM	1.038	0.456	0.051	2.132	8.835	97.206	100000***	270
MI_GM	1.048	0.472	0.051	2.516	8.027	84.591	78000***	270
EC_GM	1.001	0.037	0.847	1.223	0.872	13.290	1225***	270
TC_GM	1.047	0.469	0.051	2.441	8.150	86.512	81000***	270
markpow	0.399	0.240	0.078	0.100	0.862	2.865	33.65***	270
innov	0.046	0.050	0.001	0.350	2.682	12.422	1322***	270
ownstr	0.376	0.294	0.001	1.000	0.355	1.536	29.78***	270
propstr	0.611	0.488	0.000	1.000	-0.456	1.208	45.49***	270
assstr	0.800	0.072	0.598	0.938	-0.117	2.300	6.128**	270
liqrat	1.326	0.469	0.600	3.390	1.457	6.807	258.6***	270
assgrow	0.144	0.653	-0.878	10.008	13.103	195.245	420000***	270
shock	0.067	0.249	0.000	1.000	3.474	13.071	1684***	270

Note: *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

The total factor productivity and its decomposition efficiency in the period $t \sim (t+1)$ are defined as the explained variables in the period $(t+1)$. Thus, we finally obtained 18 cross-sectional members, 15 time points,14 variables and a total of 3990 data. Furthermore, through the unit root and other correlation tests on the variables, it is shown that the sample data are in a stationary state, thus we can conduct regression analysis.

5. Empirical Results and Analysis

5.1. Results of Corporate Sustainability Operational Efficiency Assessment

In the analysis of the overall and disaggregated indicators of the sample enterprises (see Table 2 and Table 3), we observed the following trends and results:

Firstly, the average growth rate of each indicator shows that the sustainable TFP of firms in the sample period is generally increasing, although there are slight differences in the measurement results between MM and GM models, which may be due to the difference in production frontier between developing and developed countries due to the consideration of common frontier. However, this difference does not affect the reliability of the conclusions of the comparison of corporate sustainability between developed and developing countries.

Second, the time series analysis shows that the aggregate and disaggregated indicators experienced abnormal fluctuations between 2008 and 2009, which are related to the financial and real economic turmoil triggered by the 2008 global economic crisis. In particular, it experienced a significant decline from 2008 to 2009, recovered from 2009 to 2011, and then decreased slightly after 2011 until a significant growth in 2016.

Finally, the measurement of the average value of each decomposition index shows that there is no significant difference in technical efficiency (EC) between firms in developed and developing countries, while the difference in technical progress (TC) is relatively significant. Especially after the 2008 economic crisis, the technological progress of developed countries under the GM model is significantly higher than that of developing countries, affecting the performance of the aggregate indicators. This reveals that technological progress has an important impact on the sustainable development ability of enterprises and the ability to cope with the economic crisis, and the GM model can reveal the heterogeneity brought by the technological progress of enterprises that have not been captured in the previous literature that only considers the common frontier.

Table 2. Mean value of sustainable development ability index of sample enterprises (MM model).

Year period	MM Model								
	Totality			Developed country			Developing country		
	MI	EC	TC	MI	EC	TC	MI	EC	TC
2003～2004	1.065	1.007	1.058	1.051	1.009	1.041	1.082	1.006	1.077
2004～2005	1.085	0.98	1.106	1.038	0.97	1.069	1.137	0.991	1.147
2005～2006	1.005	1.015	0.99	1.026	1.028	0.996	0.982	0.999	0.983
2006～2007	1.03	1.005	1.025	0.965	1.005	0.96	1.102	1.005	1.097
2007～2008	1.045	0.984	1.062	1.077	0.986	1.092	1.009	0.981	1.028
2008～2009	0.803	1.004	0.801	0.753	0.985	0.766	0.859	1.026	0.839
2009～2010	1.079	1.022	1.054	1.099	1.034	1.064	1.056	1.009	1.044
2010～2011	1.029	0.994	1.035	1.071	0.999	1.071	0.982	0.988	0.994
2011～2012	0.981	0.997	0.984	1.01	0.995	1.014	0.949	0.999	0.95
2012～2013	0.946	1.004	0.943	0.966	1.005	0.962	0.924	1.004	0.921
2013～2014	0.942	0.991	0.95	0.954	1	0.954	0.928	0.982	0.945
2014～2015	0.842	0.983	0.856	0.815	0.97	0.838	0.873	0.997	0.876
2015～2016	0.95	1.036	0.915	0.958	1.039	0.919	0.941	1.033	0.909
2016～2017	1.236	1.001	1.234	1.238	0.998	1.238	1.234	1.004	1.23
2017～2018	1.156	1.002	1.152	1.177	1.01	1.16	1.133	0.993	1.142
Mean value	1.013	1.002	1.011	1.013	1.002	1.01	1.013	1.001	1.012

Note: The MM model is the value measured by the Meta-Malmquist method in the RDM model. MI is the value of total factor productivity. EC is the value of technical efficiency. TC is the value of technological progress.

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Table 3. Mean value of indicators of sustainable development capacity of sample enterprises (GM model).

Year period	GM Model								
	Totality			Developed country			Developing country		
	MI	EC	TC	MI	EC	TC	MI	EC	TC
2003～2004	1.092	1.008	1.084	1.111	1.003	1.107	1.071	1.014	1.057
2004～2005	1.099	0.997	1.103	1.059	0.997	1.062	1.143	0.996	1.148
2005～2006	1.017	0.997	1.02	1.029	0.994	1.035	1.004	1.001	1.003
2006～2007	1.025	1.002	1.023	0.951	1.006	0.945	1.108	0.997	1.111
2007～2008	1.008	0.989	1.019	1.009	0.994	1.014	1.006	0.983	1.024
2008～2009	0.805	1.011	0.796	0.756	1.008	0.749	0.859	1.014	0.849
2009～2010	1.107	1.003	1.103	1.162	0.997	1.164	1.047	1.009	1.034
2010～2011	1.037	0.995	1.041	1.106	0.993	1.111	0.96	0.997	0.964
2011～2012	0.984	1.001	0.983	1.02	0.995	1.024	0.945	1.006	0.938
2012～2013	0.944	0.998	0.946	0.971	1.002	0.969	0.914	0.994	0.92
2013～2014	0.915	0.995	0.919	0.941	1.001	0.939	0.886	0.988	0.897
2014～2015	0.834	0.983	0.848	0.845	0.97	0.869	0.822	0.997	0.825
2015～2016	0.957	1.029	0.929	0.957	1.031	0.926	0.957	1.027	0.932
2016～2017	1.325	0.998	1.327	1.408	0.996	1.413	1.232	1	1.232
2017～2018	1.172	1.004	1.165	1.199	1.017	1.175	1.143	0.99	1.154
Mean value	1.092	1.008	1.084	1.111	1.003	1.107	1.071	1.014	1.057

Note: The GM model is the value calculated by the Group-Malmquist method in the RDM model, MI is the value of total factor productivity, EC is the value of technical efficiency, and TC is the value of technological progress.

As shown in Table 4, the overall and classification efficiency measurement results of the sample enterprises are as follows. The total index (MI) of each firm is greatly affected by the technological progress index (TC). Even when using different models for measurement, Rosneft, ConocoPhillips, Eni and other enterprises have higher values of technical progress and technical efficiency indicators, resulting in higher values of their total indicators, indicating that these enterprises have better sustainability. In contrast, Valero Energy, Suncor Energy, CNOOC and other enterprises also show high sustainable TFP due to the high value of technological progress index. In addition, when the total factor productivity value of a firm is lower than 1, the index values of its technical efficiency and technological progress are lower than 1. India Oil & Gas and Petrobras, have low values of technical efficiency and technical progress indicators, which leads to low efficiency of their sustainable TFP. Special attention should be paid to the fact that although CNPC has been ranked top in the petrochemical industry of Forbes 500 many times, its low technological progress value may affect its future development potential, so the enterprise should pay more attention to technological improvement in related fields.

Table 4. Total index and decomposition index value of sustainable development ability of sample enterprises.

Company	Cluster	MM			GM		
		MI	EC	TC	MI	EC	TC
SINOPEC	2	1.014	1.006	1.008	1.018	1.006	1.012
Royal Dutch Shell	1	0.999	1.002	0.997	1.034	0.999	1.035
PetroChina	2	1.000	1.005	0.996	1.001	1.005	0.997
BP	1	1.001	1.005	0.996	1.008	1.002	1.006
Total	1	0.990	0.997	0.994	1.013	0.998	1.016
Chevron	1	0.988	0.999	0.990	1.013	1.000	1.015
Rosneft	2	1.068	1.003	1.065	1.065	1.001	1.064
Valero Energy	1	1.044	1.000	1.044	1.048	1.000	1.048
Lukoil	2	1.010	1.000	1.010	1.005	1.000	1.005

Petrobras	2	0.983	0.998	0.988	0.971	0.999	0.976
Eni	1	1.019	1.006	1.014	1.065	1.004	1.060
Indian Oil	2	1.011	1.000	1.011	0.988	1.000	0.989
PTT PCL	2	1.004	1.000	1.004	0.983	1.000	0.983
Indian Oil	2	0.989	0.997	0.990	0.989	0.997	0.989
Repsol	1	1.003	1.003	1.002	1.011	0.999	1.014
ConocoPhillips	1	1.051	1.005	1.035	1.071	1.001	1.061
CNOOC	2	1.036	1.000	1.036	1.036	1.000	1.036
Suncor Energy	1	1.037	1.006	1.025	1.059	1.000	1.056

Note: Meta-Malmquist RDM and Group-Malmquist RDM model measures are shown in the table. MI represents the value of total factor productivity, EC is the value of technical efficiency, and TC is the value of technological progress. Cluster 1 is for developed countries and Cluster 2 is for developing countries.

In summary, this paper measures the sustainable total factor productivity (MI), technical efficiency (EC), and technological progress (TC) of 18 sample enterprises in developed and developing countries during the sample period with the Malmquist RDM models with negative constraints and common frontier, namely the GM model and MM model. The findings demonstrate that this method solves the issue of the regular DEA's ability to measure negative data regarding listed businesses. meanwhile, this approach dynamically separates the underlying cause of corporate sustainable development restrictions, specifically, inadequate technological advancement (TC) or technical efficiency (EC). This supports H1 fully. The results further show that developed countries do not have an obvious advantage over emerging economies when it pertains to corporate sustainable development capability (MI). This remains evident since all of the firms with low MI reside in developing nations. This may be caused by the fact that developed and developing country product markets do not entirely overlap, or it could be the result of sustainability having both present and future features. Furthermore, in terms of actual viability (EC) and future development potential (TC), developed countries still have a higher ability to achieve sustainable development than developing countries, even if domestic environmental protection pressures constrain their enterprises, making them equal to developing countries' actual market survival advantage (EC). This is because developed countries have a stronger potential for future development (TC) than developing countries. According to the time trend of measurement results, businesses that have been impacted by the economic crisis now rely more on the benefits of technological advancement to reduce risks and withstand shocks from the outside world. This suggests that, in some ways, the economic crisis has a positive impact on businesses' capacity for sustainable development than a negative one.

5.2. Benchmark regression

The benchmark regression of total indicators explores the impact of global competition, market power expansion and innovation strategies on the sustainable development ability of enterprises (see Table 5).

The results show that both of them can positively promote the sustainable development ability of enterprises. The decision-making strategy of enterprises is more conducive to innovation, and the sustainable development ability of enterprises is stronger, which verifies H3. Furthermore, we can obtain the following findings based on the estimation results of the control variables. First, higher cash solvency, the shareholding ratio of the largest shareholder and the impact of the economic crisis can all positively promote the sustainable development ability of enterprises. This paper argues that the larger the proportion of assets and inventories in a firm's total assets, as well as the higher the growth rate of a firm's assets, the lower the firm's sustainability (MI). On the one hand, as higher inventory affects cash flow and profit capture, faster asset growth rate diversifies shareholders' equity. Therefore, i.e., adequate inventory reserves and corresponding asset growth rate, i.e., the basic conditions for increasing market power, may reduce the firm's future sustainability. This may lead to the fact that the market power expansion path chosen by firms to enhance their sustainability is weakened or even turned into a negative effect in practice, which validates H4.

Table 5. Analysis of influencing factors of sustainable development capacity (MMI) of petroleum enterprises in total sample.

Variable	FE_MMI	RE_MMI	HTM_MMI	OLS_MMI
markpow	1.28***	0.256**	1.028***	0.256
	(0.300)	(0.129)	（0.268）	(0.149)
innov	2.445***	2.002***	2.34***	2.002
	(0.594)	(0.538)	（0.587）	(1.842)
ownstr	-0.596***	-0.433**	-0.523**	-0.433
	(0.226)	(0.182)	（0.215）	(0.345)
propstr		-0.331***	-0.241	-0.331
		(0.119)	（0.206）	(0.265)
assstr	-2.133***	-1.517***	-2.072***	-1.516
	(0.625)	(0.437)	(0.577)	(1.118)
liqrat	0.181**	0.003	0.12	0.003
	(0.088)	(0.068)	(0.083)	(0.042)
assgrow	-0.108***	-0.093**	-0.110***	-0.093***
	(0.039)	(0.041)	(0.039)	(0.009)
shock	0.269***	0.245**	0.263***	0.245
	(0.099)	(0.105)	(0.099)	(0.204)
_cons	2.105***	2.418***	2.364	2.418**
	(0.584)	(0.456)	(0.582)	(1.039)
N	270	270	270	270
R-sq	0.25	0.16		0.16
F	3.11***			
B-PLM test		0.00		
Hausman test	37.58***			
Hausman-Taylor Test			7.98*	
Underidentification test				
Weak identification test				
Sargan statistic				

Note: FE, RE, OLS and HTM represent the fixed effect, random effect, mixed effect, and Hausmn-Taylor model, respectively. _MMI represents the estimation result of the MI index measured by the MM model as the explained variable. Standard errors are in parentheses, and *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

As shown in Table 6, market forces significantly enhance real survivability (EC) and future growth potential (TC), but innovation strategy only has a deterministic positive effect on firms' future growth potential (TC) and an uncertain effect on real survivability (EC). This paper argues that this is because firms' investment in innovation has the problem of high uncertainty and risk, and technical efficiency decreases in the short term, but long-term technological progress will be rapid and lead to an increase in technical efficiency.

The results of control variable estimation also show that the effects of equity structure, ownership structure, asset structure, current ratio, asset growth rate and financial crisis on realistic survivability (EC) cannot be determined, but the effects on future growth potential (TC) are similar to the previous results (see Table 5). This somewhat indicates that realistic survivability (EC) is more dominant in corporate sustainability (MI), which validates H4.

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Table 6. Analysis of influencing factors of technical efficiency (MEC) and technical progress (MTC) of petroleum enterprises in the overall sample.

Variable	FE_MEC	RE_MEC	HTM_MEC	FE_MTC	RE_MTC	HTM_MTC
markpow	0.107***	0.017	0.058**	1.170***	0.236*	0.921***
	(0.037)	(0.015)	(0.029)	(0.299)	(0.128)	（0.263）
innov	-0.038	-0.048	-0.06	2.502***	2.061***	2.400***
	(0.074)	(0.063)	(0.072)	(0.591)	(0.531)	（0.583）
ownstr	-0.016	-0.004	-0.005	-0.579**	-0.428**	-0.506**
	(0.028)	(0.021)	(0.025)	(0.224)	(0.180)	（0.213）
propstr		0.003	0.011		-0.335***	-0.257
		(0.014)	(0.019)		(0.118)	（0.197）
assstr	0.012	0.003	-0.002	-2.146***	-1.533***	-2.067***
	(0.078)	(0.051)	(0.064)	(0.621)	(0.432)	（0.569）
liqrat	0.009	-0.001	0.001	0.172**	0.004	0.109
	(0.011)	(0.008)	(0.010)	(0.087)	(0.067)	（0.082）
assgrow	-0.002	-0.003	-0.003	-0.106***	-0.09**	-0.107***
	(0.005)	(0.005)	(0.005)	(0.039)	(0.040)	（0.039）
shock	-0.02	-0.021*	-0.021*	0.291***	0.268***	0.284***
	(0.012)	(0.012)	(0.012)	(0.099)	(0.103）	（0.098）
_cons	0.947***	0.998***	0.978***	2.16***	2.432***	2.414***
	(0.073)	(0.053)	(0.065)	(0.580)	(0.450）	（0.572）
N	270	270	270			
R-sq	0.01	0.02		0.24	0.17	
F	0.54			2.94***		
B-PLM test		0.00			0.00	
Hausman Test	8.97			35.11***		
Hausman Taylor			5.44			7.81*
Underidentification test						
Weak identification test						
Sargan statistic						

Note: _MEC denotes the estimation results of the explanatory variables using the value of technical efficiency measured by the Meta-Malmquist RDM model; _MTC denotes the estimation results of the explanatory variables using the value of technical progress measured by the Meta-Malmquist RDM model. Standard errors are in parentheses, and *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

In summary, the benchmark regression of this paper focuses on the impact of market power expansion and innovation strategies on firms' sustainability (MI), realistic survivability (EC), and future growth potential (TC) when competing on a global scale (MM model). On the one hand, the regression results in this paper validate H2, H3, and H4. On the other hand, this verifies that the two strategies have different impacts on firms' realistic survivability and future growth potential.

The corresponding management revelation for the enterprise to choose the path of market power expansion can enhance the enterprise's sustainable development ability, which produces the results of the latter will become worse or even turn into a negative effect in the long term. In addition, technological innovation can enhance the future growth potential of a firm, and the future growth potential of a firm dominates the sustainability of a firm. Hence, we argue that choosing a technological innovation strategy for long-term practice is Pareto-optimal for firms under uncertainty.

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5.3 Further Analysis

Since developed and developing countries have different first-mover advantages and different long-term development advantages, the optimal strategic decision-making choices of firms are bound to be different. Therefore, we need to exclude the influence of developed countries' first-mover advantages and examine the heterogeneity of developing countries' firms' optimal decision-making choices in intra-group competition and global competition situations.

The total indicator heterogeneity regression explores the effects of market power and innovation strategy on firms' sustainability (MI) in intra-cluster market competition in developing countries (see Table 7). The results show that there is no significant difference from the previous benchmark regression estimates of the total indicator (see Table 5), and only the absolute values of the coefficients are significantly higher. This may be because market conditions are more tailored under the cluster approach, resulting in a higher value of the degree of improvement; it may also be because the energy market in developing countries is more promising and opportunistic, and developing country firms have greater access to that market. This further tests hypotheses H2 and H3.

The results of the control variable estimation also show similar results to those of the benchmark regression for the aggregate indicator (see Table 5), but the coefficients on equity structure, asset structure, asset growth rate and financial crisis are estimated to be less significant. This paper suggests that this is because developing country firms have fewer constraints on their market power expansion strategy and face less environmental pressure than developed country firms. This causes developing country firms to be more willing to adopt market power expansion strategies. This further validates H4.

Table 7. Analysis of influencing factors of sustainable development capacity (GMI) of oil enterprises in developing countries.

Variable	FE_GMI	RE_GMI	HTM_GMI	OLS_GMI
markpow	1.353***	0.216	0.956**	0.216
	(0.503)	(0.199)	(0.441）	(0.184)
innov	4.597***	3.68***	4.458***	3.68
	(1.214)	(1.081)	(1.201）	(3.626)
ownstr	-0.919**	-0.512	-0.82**	-0.512
	(0.389)	(0.326)	(0.379）	(0.526)
propstr		-0.358*	-0.461	-0.358
		(0.197)	(0.455）	(0.322)
assstr	-2.719**	-2.282***	-2.769***	-2.282
	(1.078)	(0.883)	(1.041）	(1.700)
liqrat	0.186	-0.069	0.124	-0.069
	(0.127)	(0.108)	（0.123）	(0.064)
assgrow	-0.091*	-0.085	-0.093*	-0.085***
	(0.053)	(0.056)	（0.053）	(0.015)
shock	0.442**	0.45**	0.446**	0.451
	(0.184)	(0.197)	（0.183）	(0.414)
_cons	2.704**	3.131***	3.074***	3.131*
	(1.062)	(0.887)	（1.052)	(1.632)
N	135	135	135	135
R-sq	0.33	0.27		0.23
F	3.83***			
B-PLM test		0.00		
Hausman test	23.14***			
Hausman-Taylor test			5.342	

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Underidentification test	18.074***
Weak identification test	3.283
Sargan statistic	1.523

Note: _GMI denotes estimates with total factor productivity values measured by the Group-Malmquist RDM model as the explanatory variable. Standard errors are in parentheses, and *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

Table 8 explores the impact of market power and innovation strategy on the real survivability (EC) and future growth potential (TC) of firms in developing countries for sustainable development. The results show a poor level of significance of the effect of market power on firms' real survival and future growth, and a significant positive effect of innovation strategy on firms' future growth potential, with an uncertain effect on real survivability. This paper argues that due to the existence of market and technological first-mover advantages in developed countries, developing countries also need to seek breakthrough competitive advantages in the field of technological innovation. This further validates H4.

Table 8. Analysis of Factors Affecting the Realistic Survivability (MEC) and Future Growth Potential (MTC) of Oil Enterprises in Developing Countries.

Variables	FE_GEC	RE_GEC	HTM_GEC	FE_GTC	RE_GTC	HTM_GTC
markpow	0.0637*	0.0048	0.0263	1.294**	0.209	0.895**
	(0.0357)	(0.013)	(0.0257)	(0.504)	（0.198)	(0.438)
innov	-0.0663	-0.0663	-0.0777	4.662***	3.747***	4.522***
	(0.0861)	(0.0706)	(0.0829)	(1.215）	(1.077)	(1.200)
ownstr	-0.0002	0.0058	0.0056	-0.922**	-0.521	-0.820**
	(0.0276)	(0.0213)	(0.0254)	(0.389）	(0.325)	(0.378)
propstr		0.0017	0.0043		-0.361*	-0.467
		(0.0129)	(0.0207)		(0.196)	(0.443)
assstr	0.0214	0.0085	0.0086	-2.731**	-2.28	-2.774***
	(0.0765)	(0.0576)	(0.0687)	(1.079）	(0.880)	(1.039)
liqrat	0.0092	0.0022	0.0047	0.178	-0.070	0.114
	(0.0090)	(0.0071)	(0.0082)	(0.128）	(0.108)	(0.123)
assgrow	0.0001	-0.00005	-0.0002	-0.09*	-0.084	-0.093*
	(0.0038)	(0.0036)	(0.0037)	(0.053）	(0.055)	(0.053)
shock	-0.0205	-0.02	-0.0203	0.463**	0.470**	0.467**
	(0.0131)	(0.0129)	(0.0128)	(0.184）	(0.197)	(0.183)
_cons	0.9434***	0.9884***	0.9743***	2.752**	3.136***	3.120***
	(0.0753)	(0.0579)	(0.0685)	(1.062）	(0.884)	(1.049)
N						
R-sq	0.12	0.07		0.33	0.23	
F	0.57			3.69***		
B-PLM test		0.00		0.00		
Hausman test	4.45					
Hausman Taylor test			5.436			7.812*
Underidentification test						
Weak identification test						
Sargan statistic						

Note: _GEC denotes the estimation of the explanatory variables using the value of technical efficiency measured by the Group-Malmquist RDM model; _GTC denotes the estimation of the explanatory variables using the value

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of technological progress measured by the Group-Malmquist RDM model. Standard errors in parentheses, and *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

The heterogeneity regression in this paper focuses on the impact of market power expansion and innovation strategies on firms' sustainability (MI), realistic survivability (EC), and future development potential (TC) when competing within developing country clusters (i.e., GM model).

We find that developing countries have greater access to intra-cluster markets and their strategic decisions lead to higher levels of upgrading. Since developing countries are less subject to environmental pressures, there are fewer constraints on market power expansion strategies, which makes them more willing to adopt market power expansion strategies to enhance the sustainability of their firms. Therefore, compared with developed countries, developing countries should consider the path of technological innovation to break through in the market competition.

5.4 Robustness test and endogeneity analysis

To eliminate possible reverse causality and enhance the robustness of the model, the paper uses the aggregate and decomposition indicators of sustainable development on the common and cluster fronts as explanatory variables for multiple tests, respectively. We also select the lagged terms of the explanatory variables with possible reverse causality as instrumental variables to control for the endogeneity. The results show that only the MI value regression model measured by the GM model fails the weak identification test, while all other models show that the instrumental variables are properly selected.

Table 9. Robustness test results.

Variables	IV_MMI	IV_MEC	IV_MTC	IV_GMI	IV_GEC	IV_GTC
markpow	0.063*	0.144*	0.072	0.05	0.0131	0.027
	(0.498)	(0.081)	(0.482)	(0.678)	(0.068)	(0.676)
innov	0.098*	0.011	0.111*	2.891*	-0.4695	2.902*
	(1.046)	(0.188)	(1.013)	(2.538)	(0.346)	(2.531)
ownstr	-0.896***	-0.025	-0.875***	-1.518***	0.0197	-1.515***
	(0.195)	(0.035)	(0.189)	(0.339)	(0.039)	(0.338)
propstr						
assstr	-0.798	-0.061	-0.732	-1.566	-0.0004	-1.523
	(0.566)	(0.101)	(0.548)	(1.017)	(0.109)	(1.014)
liqrat	0.121	0.008	0.112	0.146	0.0133	0.138
	(0.075)	(0.013)	(0.073)	(0.103)	(0.012)	(0.103)
assgrow	-0.038	0.003	-0.035	-0.02	-0.0131	-0.02
	(0.032)	(0.010)	(0.031)	(0.042)	(0.008)	(0.042)
shock	0.248***	-0.023*	0.273***	0.424***	-0.0131*	0.444***
	(0.077)	(0.014)	(0.074)	(0.135)	(0.008)	(0.134)
_cons						
N	270	270		135		
R-sq	0.16	-0.12	0.18	0.26	-0.09	0.26
F						
B-PLM test						
Hausman test						
Hausman Taylor test						
Underidentification test	58.75***	64.25***	58.75***		64.25***	35.87***

Weak identification test	19.33	14.54	19.34		14.537	12.31
Sargan statistic	2.996	4.796	4.71		4.8	2.88

Note: IV denotes instrumental variable model, _MMI, _MEC, _MTC, _GMI, _GEC, _GTC explained as before; standard errors in parentheses, *, **, *** denote 10%, 5%, 1% level of significance, respectively.

6. Discussion

This paper conducted an empirical study on the relationship between the two strategies of market power expansion, technological innovation and enterprise sustainable development. It is found that both strategies of market power expansion and technological innovation can enhance the sustainable development ability of enterprises, but the technological innovation strategy has a better and more lasting effect.

From the perspective of firms' market power expansion, this is consistent with the findings of Kaltrina Kajtazi et al. who argued that a high level of business model innovation can lead to a high level of firm sustainability [33]. Moreover, Kamarudin also argues that fierce market competition reduces firms' sustainability performance, and firms need to adopt the necessary market instruments to cope with it [34].

From the perspective of corporate technological innovation, King Yoong Lim examines the impact of technological innovation on corporate sustainability from the perspective of the duration of the company's listing by using formal survival modeling techniques, and the results of this study support the conclusions of this paper [35]. Afshar Jahanshah examines the impact of management's support for innovation management on corporate sustainability from the perspective of management's support for innovation management, and the results of this study significantly support the conclusions of this paper.

From the perspective of market power expansion and technological innovation choices of enterprises, the innovation process in enterprises, whether based on technological innovation or market-oriented business model innovation, pays more attention to the values and expectations of enterprise stakeholders. This indicates that both technological innovation and market model innovation can promote the sustainable development of enterprises to a certain extent [22,36].

7. Conclusions

As the Russia-Ukraine conflict continues, the Palestine-Israel conflict intensifies, the international political and economic situation becomes tense, the trade environment deteriorates, and the long-standing fact of global economic recession becomes particularly prominent. How to ensure economic recovery under the premise of ensuring ecological sustainability is not only a concern of national policymakers and the public but also a problem faced by enterprises. That is, how do enterprises ensure their sustainable development on the premise of reducing the external negative effects on society and the environment? In this context, using 18 large listed petrochemical companies from 2003 to 2018 as research samples, this paper empirically examines the impact of market power expansion strategy to improve the actual survival ability and technological innovation strategy to improve the future development potential of the sustainable development ability of enterprises.

The conclusions of this paper are as follows: firstly, the stronger the enterprise's market control ability is, the higher the enterprise's sustainable development ability is. The more strategic decision-making of enterprises depends on technological innovation, the stronger the sustainable development ability of enterprises is. From the perspective that the basic practice conditions of the market power expansion strategy reduce the future sustainable ability of enterprises, the durability of the enterprise market power expansion strategy on the improvement of the sustainable development ability of enterprises is poor compared with the technological innovation strategy, and the long-term practice may lead to the occurrence of negative effects. Secondly, the future development potential of the enterprise occupies a dominant position in the sustainable development ability of the enterprise, and from this perspective, the role of technological innovation strategy is

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more important for the sustainable development ability of the enterprise. Thirdly, even if the actual market viability of enterprises in developed countries is not different from that of developing countries due to the constraints of domestic environmental protection pressure, their strong future development potential makes their sustainable development ability more prominent. Fourthly, although the actual market viability of enterprises in developing countries is not different from that of developed countries due to the low pressure of environmental protection and the fewer constraints of market power expansive strategy, they are more inclined to use market power expansive strategy to promote the sustainable development ability of enterprises. The promotion effect that this strategy can achieve is limited, whether it is in the global market or regional markets among developing countries, and it is a more feasible strategy for enterprises in developing countries to seek breakthroughs in market competition through technological innovation.

Based on the above research results, this paper puts forward the following suggestions:

First of all, from the perspective of sustainable development of enterprises, the path of innovation strategy development is better than the path of market power expansion. At the same time, in addition to strategic choices, it is the fundamental way to enhance the sustainable development ability of enterprises and enhance their core competitiveness to form a good ecological chain of scientific research and innovation and create a good ecological environment for scientific research and innovation in a planned, step-by-step, accumulated and sustainable manner.

Secondly, although there is no significant difference in the actual viability of large petrochemical enterprises in developing countries and developed countries in the current period, their future development potential is worrying.

Thirdly, while improving their sustainable development ability through technological innovation, large petrochemical enterprises in developing countries should also comprehensively improve their organization, operation, management concept, personnel incentive system and other aspects.

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