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OPEN INNOVATION AND EXPORT PERFORMANCE: THE MEDIATING ROLE OF BUSINESS MODEL INNOVATION

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ABSTRACT

Customer churn is a severe problem for service companies since losses have a direct impact on profitability, revenue and long-term competitiveness. This research has created an interpretable machine learning model for customer churn prediction and designed a targeted retention strategy accordingly. The trained and evaluated four supervised learning models were Logistic Regression, Decision Tree, Random Forest and XGBoost and the following metrics were used for evaluation: Accuracy, Precision, Recall, Specificity, F1-Score, Balanced Accuracy, Matthews correlation coefficient, ROC-AUC and Precision–Recall AUC. XGBoost had the best overall predictive performance with ROC-AUC of 0.8545, PC-R AUC of 0.6724, PC-recall of 0.7941 and an F1 score of 0.6339 out of all the models evaluated. Explainability was added in the form of a SHapley Additive exPlanations (SHAP) analysis to highlight the key global and customer-level factors that affect churn. All the following were among the most influential: month-to-month contracts, short tenure, no dependents, higher monthly charges, fibre-optic internet service, electronic-check payment, no online security, and no online technical support. Customers were also separated into 4 groups: low risk, moderate risk, high risk, and critical risk according to their expected churn rates. Churn rate in the critical-risk segment was 71.74% while it was 2.17% in the low-risk segment. The results show the potential of explainable machine learning for enhancing customer churn prediction and managerial decisions by associating customer risk scores with interpretable churn drivers and value-based retention actions.

Keyboard: Customer churn; customer retention; explainable artificial intelligence; machine learning; customer segmentation; predictive analytics

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1. Introduction

Organizations are faced with growing and complex markets, where innovation has emerged as one of the major sources of competitiveness. There have been significant changes in customer expectations, technological innovations, and increased competition, which have led to a shift in strategy for many organisations from relying solely on internal research and development to seeking new ways to innovate. Open innovation has thus become a strategy that companies use to gain external knowledge, technologies and connections, to enhance the capacity for innovation and organizational performance (Oltra et al., 2018). It is also critical in international markets, where companies need to be flexible with the preferences of various markets and are competing against a range of companies. To be successful in export markets, an organisation needs to continuously adapt its products and services and be able to differentiate them. With the increasing volume of international trade, innovation is a key skill for maintaining export competitiveness and long-term growth (Amani & Yawar, 2025). Organizational strategy to these challenges is business model innovation. It doesn't just deal with new products or new technologies; it is about redesigning how firms generate, deliver and claim value. Business model innovation enhances firms' competitive positions by improving their organizational processes, the use of the resources that they have on hand and the ways in which they generate revenues, alongside technological innovation (Foss & Saebi, 2018). Digital technologies have also helped organizations further transform their business models, as they have made it easier for them to involve customers, suppliers and strategic partners in innovation processes, thus creating more value creation opportunities (Ibarra et al., 2018).

However, open innovation has been the subject of much research as it enables companies to leverage external knowledge sources with their own internal resources. Organizations that work with customers, suppliers, universities and research institutions are better equipped to come up with new ideas and optimize organizational results. The advantages of open innovation are correlated not just to the knowledge-enriched outcome, but also to the organizational arrangements to effectively integrate and commercialize that knowledge (Moretti & Biancardi, 2020). One of these mechanisms is called "business model innovation". It helps companies modify their value propositions, business models and operations to better meet shifting market needs. Consequently, the study on business model innovation is an important topic since it enables the organization to convert innovation into business value, which can be realized sustainably (Ramdani et al., 2019). With the spread of digital technologies, this process has gained further momentum through the capabilities of digital information facilitating decision-making and more flexible business models that enable organizations to become more competitive (Sorescu, 2017). Digitalization also has expanded the strategic nature of business model innovation as it allows companies to combine technological innovation with sustainable organizational innovation (Parida et al., 2019). Export behavior has also been related to innovation. Companies that have higher innovation capacity tend to be more competitive on the international market by offering more

differentiated products, being more efficient in operating and being more responsive to international customer needs. Studies have already shown that innovation has a positive effect on the external competitiveness of companies, especially in times of great economic uncertainty (Brancati et al., 2022). Likewise, export performance has always been found to be a key determinant of innovation-based competitiveness in various economic environments, suggesting that innovative companies are more likely to achieve better export results (Bierut & Kuziemska-Pawlak, 2017). Innovation also, it could be inferred from the available sectoral evidence, has the positive effect of improving productivity, product quality and market response, which is key for export growth (Bottega & Romero, 2021). However, the way firms apply the concept of business model innovation is significantly different, suggesting that business model innovation's impact on organizational performance could differ based on strategic and organizational conditions (Ibarra et al., 2020).

While previous research has found positive links between openness of innovation, business model innovation and export performance, the three have been studied separately. So far, little is known about how business model innovation is actually the vehicle for open innovation to boost export performance. Therefore, the relationship between the three constructs is indirect and needs more understanding. Filling this gap is crucial as understanding the role of business model innovation could contribute to a better understanding of how firms can translate open innovation into better export performance. It is thus important to analyze both direct and indirect linkages in one analytical framework, which is useful for enriching the existing literature on innovation and international business.

In this context, this study takes a look at the relationship between open innovation and export performance and the mediating function of business model innovation is examined in this process. More specifically, it explores open innovation's ability to foster business model innovation, whether this relationship is direct, and if so, how; whether open innovation directly impacts export performance, and how; and whether business model innovation mediates the relationship between open innovation and export performance.

2. Methodology

2.1 Research Design

This study was quantitative, explanatory and secondary cross sectional survey with a development approach. The design was appropriate in that the study was about the relationship between two constructs (open innovation and business model innovation) and export performance and the study was designed to test the mediating effect of business model innovation between open innovation and export performance. The analysis concentrated on the responses of the firms and employed statistical techniques that are appropriate for latent constructs that are measured with multiple items.

2.2 Data Source

All the data were taken from an open research dataset provided by Pinera Salmeron and Sanz Valle (2024). The data includes individual firm answers to surveys about open innovation, business model innovation, export performance and some organizational characteristics. A codebook and questionnaire were provided with the documentation that assisted in identifying and interpreting the variables that were analyzed.

2.3 Measurement and Research Instruments

This dataset was originally observed at the firm level, and there were 196 observations. The number of observations indicated the number of responding firms. Following the removal of the missing values for the composite measures and control measures, 187 complete observations remained for the main between-measures regression and mediation analyses. This is 95.4% of the original sample.

2.4 Measurement of Variables

Open innovation was captured with six items grounded on the four aspects of searching, acquiring, sharing and collaborating around external technological and innovation-related knowledge. Business model innovation was assessed with ten questions related to value offering, value architecture and revenue model. The export performance was measured using five indices which reflect the volume of foreign sales, foreign sales ratio, export profitability, export geographic scope, and attainment in export goals. The construct items were positively coded, and all items were measured on seven-point scales. Items for each were aggregated into a composite score, using the mean. A score was calculated when at least 80% of items were available for a construct. The control variables consisted of firm age, export experience, export breadth, firm size and family-business status. The family-business status was dichotomized (1 = family business, 0 = other).

2.5 Data Screening and Measurement Assessment

The data were initially checked for possible duplication, missing values, out-of-range responses, and low variation responses. No duplicate "respondent" identifiers were identified. There were only a few items and control variables that were missing and only a small proportion of individuals. Cronbach's alpha was used to analyze the internal consistency. The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity were used to test the constructability. Three open-innovation, three business model innovation and three export performance one-factor exploratory factor analyses were then estimated. Prior to the development of composite scores, the following were analyzed: item loadings, communalities and explained variance.

2.6 Statistical Analysis

Main constructs and control variables were measured using descriptive statistics. Bivariate relationships were tested with Pearson correlations, and multicollinearity was tested by looking at variance inflation

factors and tolerance values. Ordinary least squares regression with HC3 heteroskedasticity robust standard errors was used to test the hypotheses. Three models to estimate were described. The first one examined the effects of open innovation on business model innovation. The second estimated the overall effect of open innovation on export performance. The third one dealt with open innovation and business model innovation as a predictor of export performance, controlling for firm characteristics. Five thousand (5000) bootstrap resamples were used to estimate the mediation effect. The indirect effect was calculated as a multiplication between the effect of open innovation on business model innovation and the effect of the business model innovation on export performance. The indirect effect was considered statistically supported when the 95% bias-corrected bootstrap confidence interval for the indirect effect did not include the null value.

2.7 Robustness Analysis

Robustness checks were conducted separately for each possible mediator. The composite scores were recalculated using only complete item responses, with the exception of straight-line responses, in additional sensitivity analyses. The findings were evaluated for the influence of the operationalization of the mediator and the incomplete responses on the conclusions.

3. Results

3.1 Measurement quality and descriptive properties

Measurement assessment results indicated good internal consistency and factorability for measures of each of the study constructs. All Cronbach's alpha values were higher than the normal criterion of 0.70, with the values ranging between 0.917 for export performance and 0.953 for business model innovation. The Kaiser–Meyer–Olkin statistics varied between 0.898 and 0.943, and all of the Bartlett's tests of sphericity were statistically significant for each construct. The results support the validity of the sets of items in use for measuring them as factors and in the development of composites from them. The three extracted one-factor solutions accounted for 74.4% of the variance of open innovation, 67.9% of the variance of business model innovation and 69.0% of the variance of export performance. Regarding constructs, they were higher than the midpoint of the scale, with business model innovation, followed by export performance, outperforming open innovation. In Table 1, the reliability of the main constructs and the factors' characteristics are reported.

Table 1. Construct reliability, factorability, and descriptive statistics

Construct	Items	N	Mean	SD	Minimum	Maximum	Cronbach's α	KMO	Variance explained	Bartlett χ^2	Bartlett p

Open innovation	6	196	4.569	1.163	1.000	6.333	0.945	0.902	0.744	1086.650	<0.001
Business model innovation	10	196	4.976	1.094	1.400	7.000	0.953	0.943	0.679	1817.564	<0.001
Export performance	5	196	5.061	0.953	2.400	7.000	0.917	0.898	0.690	648.236	<0.001

Note: KMO = Kaiser–Meyer–Olkin measure of sampling adequacy. Variance explained refers to the proportion of variance accounted for by the one-factor solution.

There were no substantial floor or ceiling effects in the distributional assessment. Compared to the other constructs, open innovation showed the highest negative skewness, with most responses coming from the top half of the scale. The performance of exports was more or less similarly distributed, with business model innovation at a moderate level between around 4.5 and 6.0. The distribution of open innovation is shown in Figure 1A with its mean and median. The mean and median of the business model innovation distribution are presented in Figure 1B. Following this, the distribution of export performance is shown with the average and median shown in Figure 1C.

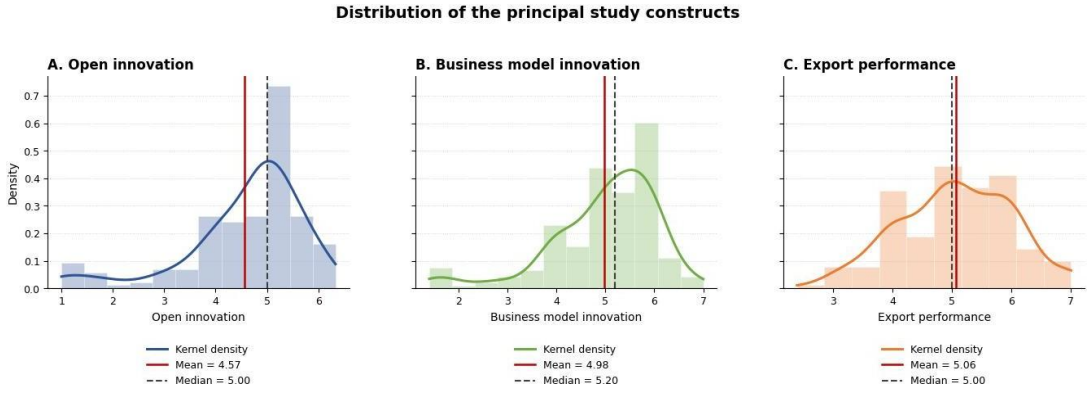

Figure 1. Distribution of the principal study constructs: (A) Open innovation; (B) Business model innovation; (C) Export performance

3.2 Correlations and multicollinearity diagnostics

The bivariate results indicated a positive association between open innovation and business model innovation ($r = 0.376$, $p < 0.01$) as well as a positive association between open innovation and export performance ($r = 0.349$, $p < 0.01$). In addition, there was a positive correlation between business model

innovation and export performance, but the correlation was not as strong, r = 0.202, p < 0.01. Among the control variables, export breadth showed the strongest positive association with export performance (r = 0.316, p < 0.01). Family-business status was also positively associated with export performance (r = 0.174, p < 0.05), whereas firm age, export experience, and firm size were not significantly associated with export performance. Export experience was negatively associated with open innovation. Moderate correlation between firm age and export experience (r = 0.590) was seen, and none of the other correlations was greater than 0.70, which is the threshold value to consider possible collinearity problems. The variance inflation factors were within the range of 1.042 to 1.682. These values were quite low and below the conservative value of 5.0, suggesting that multicollinearity would not be expected to affect the estimates in the regression. The Pearson correlations and variance inflation factors (VIFs) of the study variables are presented in Table 2.

Table 2. Pearson correlations and multicollinearity diagnostics

No.	Variable	1	2	3	4	5	6	7	8	VIF
1	Open innovation	1.000								1.241
2	Business model innovation	0.376***	1.000							1.236
3	Export performance	0.349***	0.202***	1.000						—
4	Firm age	-0.020	0.145**	0.071	1.000					1.585
5	Export experience	-0.150**	0.074	-0.046	0.590***	1.000				1.682
6	Export breadth	-0.026	-0.013	0.316***	0.152**	0.252***	1.000			1.192
7	Firm size	0.043	0.171**	0.088	0.119	0.210***	0.346***	1.000		1.198

Note: Pearson correlations are presented below the diagonal. Diagonal values equal 1.000. *** p < 0.01, ** p < 0.05, * p< 0.10. Variance inflation factors (VIFs) are reported only for predictor variables; no VIF is reported for the dependent variable (Export performance).

The first regression model was the open innovation – business model innovation model. The coefficient of open innovation was 0.354 with a high confidence interval (HC3 SE = 0.073, 95% CI = 0.211 to 0.498) and was positive and statistically significant. This result was in line with H1. The model accounted for 19.1% of the variance in business model innovation, and had an adjusted R^2 of 0.164. The second model estimated the overall relationship between export performance and open innovation. H2 was confirmed with results indicating that open innovation was positively related to export performance (b = 0.307, HC3 SE = 0.060, p < 0.001). A 95% confidence interval for the difference is (0.188, 0.426). The model explained 29.0% of the variance of export performance. The positive relationships between open innovation and export performance were not significantly changed by

business model innovation or the control variables; the results for the third model were: b = 0.277; HC3 SE = 0.067; p < 0.001. However, the effect of business model innovation on export performance was not significant, b = 0.083, HC3 SE = 0.070, p = 0.235. The confidence interval on it included the value of zero (-0.055, 0.222). H3 was thus not approved. A bootstrap indirect effect was 0.030 (bootstrap standard error 0.025) for this. The 95% bias-corrected confidence interval was within 0. (-0.017, 0.084). Thus, the mediation hypothesis was not confirmed. In order to examine the hypotheses H1–H4, the regression and bootstrap mediation results are reported in Table 3.

Table 3. Hypothesis-testing and mediation results

Hypothesis	Relationship	Estimate	Robust/Bootstrap SE	p-value	95% CI lower	95% CI upper	Decision
H1	Open innovation → Business model innovation	0.3544	0.0729	<0.001	0.2106	0.4981	Supported
H2	Open innovation → Export performance	0.3070	0.0604	<0.001	0.1878	0.4263	Supported
H3	Business model innovation → Export performance	0.0834	0.0700	0.2351	-0.0548	0.2216	Not supported
H4	Open innovation → Business model innovation → Export performance	0.0296	0.0253	0.1876	-0.0170	0.0845	Not supported

Note: H1–H3 were estimated using ordinary least squares regression with HC3 heteroskedasticity-robust standard errors. H4 reports the indirect effect based on 5,000 bootstrap resamples and a 95% bias-corrected confidence interval.The path structure is estimated and shown graphically in the model. The path model demonstrated that there are significant positive relationship between open innovation and business model innovation and significant direct relationship between open innovation and export performance. The path from business model innovation to export performance was not statistically significant, however, and the indirect path also was not statistically significant as the confidence interval for the pathway contained zero. The estimated direct and indirect relationships exist between the three major constructs as illustrated in Figure 2.

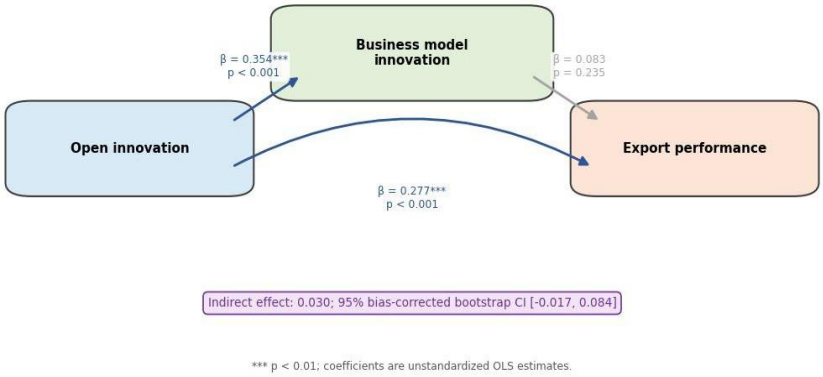

Figure 2. Estimated relationships among open innovation, business model innovation, and export performance

3.4 Effect-size and mediation-interval assessment

The coefficient plot represents the estimated effect sizes and uncertainty in an estimated effect size in a comparative manner. The confidence intervals of the open innovation coefficients in all three models (business model innovation, total-effect and direct-effect) were positive. The confidence interval for the business model innovation coefficient, however, did not include a zero result, in accordance with the nonsignificant regression result. The regression coefficients and 95% confidence intervals for the main direct relationships are presented in Figure 3A. The bootstrap interval plot also reveals that both the percentile interval and bias-corrected interval for the indirect effect included the value of zero. The two intervals are quite close, suggesting that the mediation conclusion is not sensitive to the chosen bootstrap interval analysis. The percentile and bias-corrected bootstrap 95% confidence intervals of the indirect effect are presented in Figure 3B.

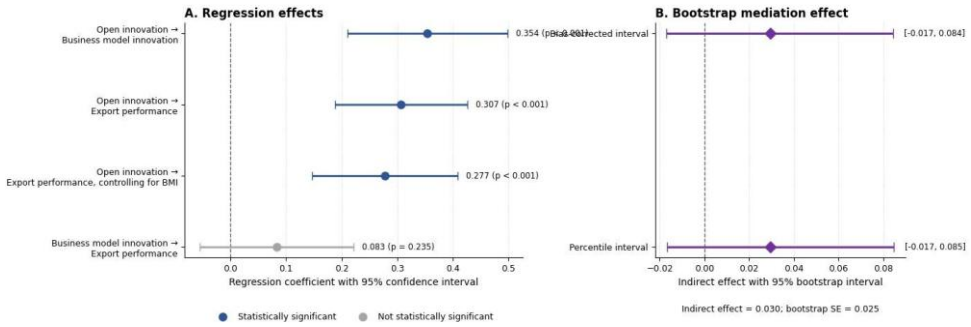

Figure 3. Regression estimates and bootstrap mediation results: (A) Regression effects; (B) Bootstrap mediation effect

4.Discussion

The empirical results indicate positive associations between open innovation and business model innovation and export performance. Given that open innovation shows a positive association with business model innovation, active OI efforts should be positively correlated with more active business model innovation. Research has validated this link, and it is believed that openness can be used to help companies access a broader range of ideas and resources and, in turn, the chance to change business models. The fact that open innovation has a positive overall impact on export performance also suggests that companies with external innovation inputs could have greater opportunities for achieving positive export performance. The results offer a fresh look at export performance and the role that business model innovation plays. When open innovation and the control variables were added to the model of export performance, however, business model innovation did not have a statistically significant independent effect. The same result was found with the bootstrap analysis (the 95% confidence interval for the indirect effect was 0). However, there was a fairly high direct relationship between open innovation and export performance. Such results suggest that the effects of open innovation on export results of the observed companies happen more directly rather than by business model innovation. Also, the sensitivity analysis has to be carefully interpreted. Straight-line responses were excluded from the mediation effect and the three components of business model innovation were analyzed individually, which did not support the mediation effect. Significant indirect effects were found only for the composite scores (to responses for all items). This is an encouraging, but isolated result that indicates some sensitivity to the handling of missing responses, but isn't enough to change the main result. The results therefore indicate that there is a direct connection between open innovation and export performance, and the direct role of business model innovation is not entirely clear.

This positive influence of open innovation on export performance is in line with previous studies showing that open innovation strategies can enhance firms' international competition capabilities. Edeh et al. (2020) found that firms' ability to respond to external export opportunities is improved through innovation strategies, and Ayob et al. (2023) showed that innovation is a factor that drives export activity even in the face of the constraints of trade. The results of the present study support this argument as openness to external innovation resources is directly related to export performance. In addition, the positive correlation between open innovation and business model innovation also fits in with studies that have focused on complementarities of external knowledge acquisition and organizational reconfiguration. Lu et al. (2024) revealed that innovation performance is positively related to organizational capabilities, which affect the way external knowledge is captured and utilized, and that open innovation facilitates innovation performance. Similarly, Gkypali et al. (2018) found that absorptive capacity and exporting also moderate the relationship between innovation openness and value creation, indicating that innovation openness has a positive effect only when firms have the capacity to convert external inputs into organizational outputs. The negative result of the non-significant relationship between business model innovation and export performance needs a more nuanced

interpretation. International-business-focused research in recent years has provided some evidence that business model innovation does not have a consistent performance impact on companies. Najafi-Tavani et al. (2025) prove that the export impacts of business model innovations are a function of how firms structure and implement their changes in business models, and Jean et al. (2024) illustrate the context-specific effects of business model innovations on firms' performance in foreign markets as a function of institutional environments and entrepreneurial orientation. It is not, therefore, surprising that there is no strong direct effect here. More broadly, relationships between innovation and performance are influenced by the mix of technological, organizational and strategic capabilities. Altuntas et al. (2018) identified the interdependencies between advanced manufacturing technology, innovation, export activity and firm performance. Pundziene et al. (2022) also demonstrated that open innovation can be an intervening variable between the DCS and competitive performance. These findings collectively indicate that business model innovation could be one of multiple potential pathways to international outcomes that companies take when they make their business open.

Results are of relevance to those concerned with innovation management and export strategy. Theoretically, they present the differences between the potential that open innovation has to drive business model change and the potential that business model change has to drive export gains. The results show that openness may relate to improved international performance without having to go through business model innovation. Open innovation seems to be valuable in its own right, and the performance contribution of business model innovation could be dependent on a complementing capability or context. For managers, the results indicate that external collaboration, knowledge sourcing, and innovation partnerships can complement a non-reinventing business model when firms do not significantly change their business models. Business model innovation should consequently not be seen as a given or a prerequisite for export success, but as part of a company's consideration of changes in its business model in relation to the particular market requirements of the export markets.

There are a few limitations to be noted. The data is analyzed at a single point in time and are cross-sectional, so this does not allow causal interpretation. The principal constructs were based on self-reported survey measures, and the available sample consisted of a particular sample of firms and not of all exporting firms. Longitudinal data could be utilized to investigate the consequences of open innovation, such as the timing of business model changes and export outcomes and whether environmental dynamism, absorptive capacity, digital capacity, and market uncertainty influence the timing of business model innovation as a source for export performance.

5.Conclusion

Open innovation became a significant factor in business model innovation and export performance. Companies that interact with the external knowledge and innovation ecosystem more actively seem to be in a better position to support their foreign business models and increase foreign business success.

The findings also indicate that business model innovation does not possess a statistically significant effect directly on export performance in the primary model. Business model innovation, however, was not a significant predictor of export performance in the primary model and did not lead to any significant indirect effect in the bootstrap analysis. This means that open innovation can also and perhaps more fundamentally affect export performance in other ways than business model innovation or that export performance will be affected by other organizational and market factors if there is a business model innovation. The positive strategic consequences of opening up for internationally active companies and warn against the false conclusion that innovation in business models means innovation activities result in export success. Future research should look at the circumstances when business model innovation is more likely to be a critical link between openness and international performance.

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