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Business Innovation in Commercial Space: Culture and Trends in Earth Observation

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Abstract

This work studies technological, business, and cultural development practices in the commercial Earth Observation (EO) sector. Growing demands for climate and natural resource monitoring, situational awareness, on-demand analytics, and sovereign data independence motivate greater scrutiny into the culture and trends of innovation. The financial performance and culture of five public EO companies–iQPS, GOMSpace, Kleos Space, Planet Labs, and Satellogic–are analyzed. Time-series econometrics modeling indicates trends in how financial resources impact earnings and revenue, and the models are used to forecast future earnings and revenue with a high goodness-of-fit. This analysis revealed distinct patterns in financial data for successful and unsuccessful companies. A time-series DuPont analysis shows how companies operate through conversion of different financial instruments, and corresponding corporate milestones contextualize these financial transactions. Informational interviews of four EO company executives probe how to balance a culture of innovation with risk mitigation for successful commercialization. Recommendations tailored to the unique challenges and opportunities of the global EO sector are provided to help government partners, investors, and program managers estimate business performance given financial and cultural data.

Keywords: Innovation, Commercial Earth Observation, Satellites, Space Program Management, Space Econometric Analysis

1. Introduction

Reduction in product development costs and launch expenses is driving growth in commercial space. These reductions paved the way for the emergence of a commercial Earth Observation (EO) market over the past decade. The deployment of small satellite mega constellations now provides an affordable means of continuously observing the Earth, offering on-demand data to supports a range of sustainable business opportunities beyond the traditional defense and telecommunications sectors. The development of viable business models in EO requires addressing the financial risks associated with building and launching space hardware, enhancing the value delivered to customers, and diversifying the types of products and services space-based assets can provide [1]. This work focuses on the role of innovation in overcoming these challenges, examining how technologies and business models contribute to the success of EO companies. It assesses the financial health and business strategies of EO companies with an emphasis on milestones linked to growth and development.

This work analyzes financial data from five EO companies and compares insights from four informational interviews with EO company executives to identify business development strategies. It shows the importance of cultivating innovation in both technologies and business models for sustainable growth. Findings are supported by the public release of financial data and code[1]. This study aims to guide emerging EO companies through innovation cultivation and financial sustainability insights essential for thriving in this competitive landscape.

[1] Financial data and code are available at github.com/hollydinkel/space_econometrics.

1.1 Paradigms of Innovation

Innovation is multifaceted, encompassing technologies, business models, and corporate culture. Changes in society can be viewed as paradigm shifts [2]. The technological foundation of innovation is connected with its societal impact, requiring both material advancements and societal acceptance for progress to be recognized as innovation. These developments occur in step-wise sequences, where a step in a scientific discipline represents a change in scientific perspective. This work considers three paradigms of innovation in the development of the commercial EO market. The first is technological innovation as it relates to core products. The second and third paradigms, business and cultural innovation, relate to the business practices and executive decisions impacting corporate performance as much or more than core technologies.

Technological innovation involves continuous refinement of technologies through either incremental or disruptive innovation. Incremental innovation is iterative improvement in technology to enhance performance, function, safety, or reliability. In contrast, disruptive innovation challenges existing practices and can potentially replace incumbent technologies. Incremental innovation progresses at varying rates as functions of market maturity, eventually reaching an asymptote where significant Research and Development (R&D) investments yield marginal improvements. Disruptive innovation typically starts low performance and high cost, yet surpasses incumbent technologies upon maturity. Disruptors then engage in incremental innovation, beginning a new cycle [3] as shown in Figure 1.

A prominent example of disruptive technological innovation is Artificial Intelligence (AI), which is transforming various sectors. In manufacturing, AI-based image recognition is used for automated defect detection, while in finance, AI enhances fraud detection, risk analysis, and operational efficiency. A study identified major EO applications of deep learning in remote sensing, including image fusion, land cover classification, and image segmentation [4]. These applications achieve high-frequency, high-resolution data acquisition, further accelerating the capability for solving various challenges. However, the amount of data generated by EO applications can exceed the communication capabilities of smaller satellites, leading to congestion and data dropping. Data pre-processing using AI onboard the satellite computer prior to downlink improves downlink efficiency by discarding unwanted information.

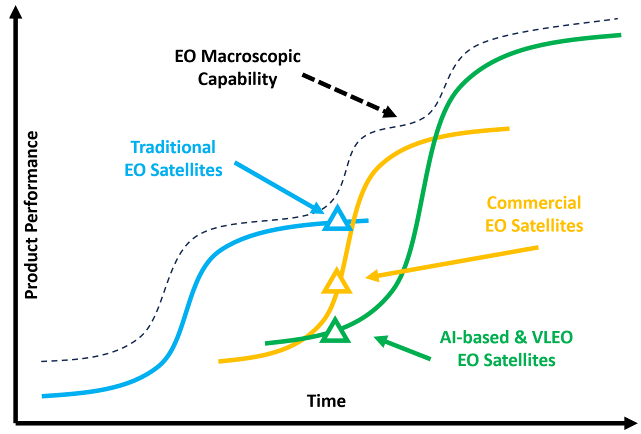

Figure 1: Disruptive innovation in data analysis or satellite orbit may begin with lower performance and higher cost, but upon maturity it may pass incumbent EO technologies. Disruptors then engage in incremental innovation, beginning a new cycle.

The examples of satellites 6U CubeSat HYPSO-1 the OPS-SAT highlight the disruptive potential of the use of on-board AI [5, 6, 7, 8].

Business innovation is initiating organizational change to create competitive advantage and market differentiation. Unlike technological innovation where the innovation is recognizable in the end product, business innovation usually manifests in product commercialization and monetization strategies. Two significant space business innovations are vertical integration and service-oriented business models [9]. Vertical integration consolidates production to optimize operational efficiency and supply chain control [10, 11, 12, 13]. One company effectively invoking vertical integration is SpaceX, which manages manufacturing, launch, and operations of its rocket and satellite segments entirely in-house [14]. The goal of this consolidation is to make it as easy as possible for customers to adopt space-based solutions into their workflows.

This underscores a shift from space product to space service business models with space companies transitioning from offering tangible goods to intangible services [15]. Space-based service models may require high initial effort in terms of industrialization cost, however they offer exciting benefits such as improved market understanding and higher sales margins than space-based product-based models. The theme is users benefit from access to space without directly managing complex space manufacturing and operations. Examples of operational service-based space businesses include Planet Labs and Satellogic (Software-as-a-Service), ISISpace and Spire Global (Satellite-as-a-Service), and KSAT and Azure Orbital (Ground Station-as-a-Service). Vertical integration and service models often coexist, offering more value from combination.

Cultural innovation is changing the shared values and norms of the organization. When established companies decline following a technological disruption, it is likely because of culture. Risk aversion and management inertia can make organizations process-heavy, hampering their ability to adapt [16]. Start-ups cannot claim long heritage or industrialized processes, but instead have a bold risk-taking culture. The emergence of the NewSpace ecosystem brings new energy, creativity, and dynamism to the space industry [17]. The NewSpace ecosystem is a cultural innovation which reduces barriers to entry for participation in space. The NewSpace ecosystem tolerates more risk in space manufacturing and qualification in favor of speed and reduced cost, inviting innovation from start-ups [18, 19, 20]. Established companies can also adopt NewSpace approaches, although this may require a strong change in company culture and high industrial conversion costs.

One form of cultural innovation is changing management techniques to change organizational structures and processes [21]. One example of this management innovation is the adoption of the Agile methodology in space hardware development. The Agile methodology is project management which breaks projects into several sprints and delivers a Minimum Viable Product (MVP) at the end of each sprint [22]. The use of Agile practices from SpaceX propelled the company to global leadership across multiple space sectors [23].

1.2 Environment Drivers

Innovation is market-driven, and unmet customer needs are the driver. These needs can arise from technological hype and customer preferences [24, 25]. This section examines technological hype and customer expectations as environmental drivers of innovation.

The Gartner hype cycle is often used to describe the adoption and maturation of emerging technologies. It reveals technologies typically follow a pattern of initial over-enthusiasm followed by disillusionment as early implementations fall short of expectations. The journey through the Gartner hype cycle varies depending on factors such as technological progress, regulatory changes, and market demand. Some technologies rapidly achieve widespread adoption, while others face long adjustment periods [26]. The Gartner hype cycle is shown for EO satellite technologies in Figure 2 [27].

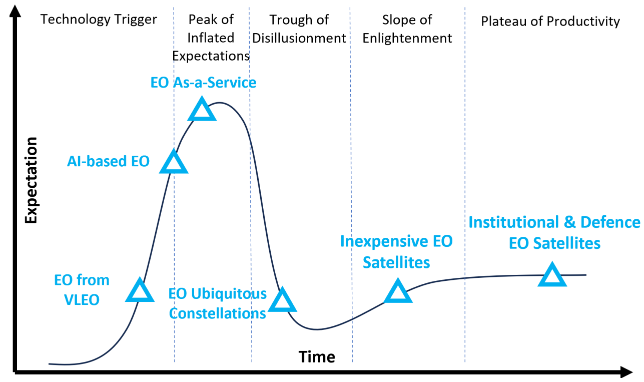

Figure 2: A Gartner hype cycle highlights a the stages of maturity and market adoption for a technology [27, 28]. In the EO Gartner hype cycle, observation from Very Low Earth Orbit (VLEO) is a technology trigger while EO services and AI/Edge-based EO are nearing the peak of inflated expectations. Ubiquitous constellations are emerging, with more mature and cost-effective EO satellite technologies gradually moving toward the plateau of productivity to reach institutional markets.

The SkySat constellation, originally developed by Skybox Imaging and ultimately acquired by Planet Labs, exemplifies this cycle, sparking a wave of commercial EO startups capitalizing on market hype.

Customer expectations drive innovation. Companies must fall in love with customers and their unmet needs, exceeding their expectations by introducing new products and services [29]. Disruptive innovations often challenge established customer bases, requiring innovators to cultivate new customer relationships [30, 31]. Competition for customers significantly influences innovation as companies continuously introduce features, designs, and technologies to meet their needs. The insatiable market demand for innovation ensures technologies evolve in direct response to user needs. The market benefits from increased demand, and blossoming user engagement means innovation will adapt to cater to a wider range of users. What ultimately matters is building a diversified, robust customer chain through empathizing with current and predicting future needs.

1.3 Exploiting Innovation

Having identified the environmental drivers of innovation, the next step is to translate innovation into commercial success. Success varies depending on type of company and its development stage. For hard- and deep-technology companies (including nearly all space companies), achieving financial viability takes time.

For startups, the value of the product portfolio and the growth potential of the company are strongly signalled through acquisition or going public, though even publicly-traded companies face financial challenges.

The relationship between innovation and commercial success is characterized by recurring mechanisms and tools that companies employ with varying results. After defining innovation (Section 1.1), and discussing how it is perceived (Section 1.2), the remainder of this paper analyzes this relationship through quantitative and qualitative data from public sources and interviews with company executives. The findings are discussed, followed by recommendations and conclusions.

2. Methodology

This work presents a quantitative analysis of corporate financial data for five global EO companies and a qualitative analysis of executive interviews from four global EO companies. The primary research question is: how sensitive is company performance to its operating conditions? The first hypothesis is increased availability of capital–in the form of assets, debt, and equity–improve company performance. Time-series data for each company are compiled and modeled (Section 2.1) and operational performance indicators are analyzed over time (Section 2.2) to test this hypothesis. The second hypothesis is cultural innovation improves company performance. A cross-sectional analysis of executive interviews (Section 2.3) is performed to test this hypothesis.

2.1 Econometric Analysis

The financial data used in this work were compiled from public reports of five currently-operational EO companies iQPS (Japan), GOMSpace (Denmark), Planet Labs (United States of America), and Satellogic (United States of America)[2], and one formerly-operational EO company Kleos Space (Luxembourg). These were selected on the basis of geographic diversity, operating stage diversity, and data availability. Data were compiled from publicly-available financial statements and public satellite launch databases[3] and were analyzed on a quarterly basis. Missing values were linearly interpolated between neighboring points in the time series to complete the dataset.

Econometric analysis models the influence of one or more independent, exogenous variables on one or more dependent, endogenous variables. Econometric analysis of time-series data quantifies between-variables effects in multivariate systems over a period of time. In applied econometrics, the Vector Autoregressive (VAR) method, Johansen Vector Error Correction Mechanism (VECM) method, and the Autoregressive Distributed-Lag (ARDL) method are common choices for modelling between-variable effects in data. The VAR model captures linear dependencies among multiple time series variables. The VAR method requires time series data to be stationary, meaning the statistical properties of the series, such as mean and variance, do not change over time. The data can be tested for stationarity using a unit root test, such as the Augmented Dickey-Fuller unit root test [63, 64, 65]. For a VAR model to be applied to non-stationary data, the data must be transformed into a stationary time series, usually through taking the logarithm of the data or through first-order differencing. Modeling cointegration has become a requirement when non-stationary data are present in a time series. The Johansen cointegration technique was developed to identify the long-run relationship between variables which are all non-stationary and re-parameterize them to the Vector Error-Correction Model (VECM) [66, 67]. Previous work in econometric analysis of space company and agency budgets used the Johansen VECM [68, 69]. The ARDL method cointegrates stationary and non-stationary data. The procedure for selecting an appropriate model for the company time series data is shown in Figure 3. After finding the variables could not all be transformed into entirely-stationary or entirely-non-stationary time series, the ARDL model was selected using the method in Figure 3. An openly-available implementation of ARDL model fitting is used in this work [70].

The ARDL model is a robust time-series analysis technique used to cointegrate variables with different orders. The ARDL model of order p in the endogenous variable and order n in the exogenous variables, ARDL(p, n), is defined for a scalar y_t as

$$y_t = \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=0}^{n} c_i^{\intercal} x_{t-i} + \epsilon_t, \tag{1}$$

where ϵ_t is a free scalar parameter optimized to min-

[2]Satellogic was headquartered in Montevideo, Uruguay until 2023.

[3]Financial data were obtained through company-released financial reports and government filings [32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 51, 53, 54, 55, 56, 57, 58, 59]. Satellite data were obtained through public satellite launch databases [60, 61, 62].

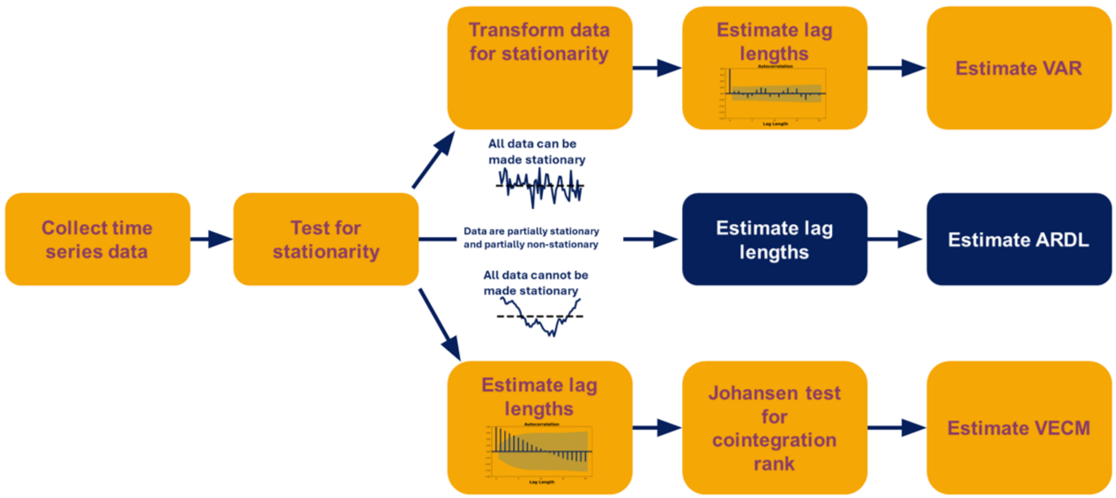

Figure 3: First, the time series data are collected and missing values are linearly interpolated to complete the dataset. Next, the time series is tested for stationarity using the Augmented Dickey-Fuller unit root test. For stationary data, the Vector Autoregressive (VAR) model is selected. For nonstationary data, the Vector Error Correction Mechanism (VECM) model is selected. For time series which are part-stationary, part-nonstationary, the ARDL model is selected. Autocorrelation is used to compute optimal lag lengths, and the model is fit through regression.

imize the root mean-squared error between the model prediction and the data and x_t is a K-dimensional column vector process [71]. The scalar coefficients, a_i, indicate how the time lags of an endogenous variable influence it, while $c_i^\intercal$ are row vectors of parameters indicating the influence of the exogenous variables on the endogenous variable.

This work seeks models representing Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA), $EBITDA_t$, at the current time step, t, as the linear combination of variables which cause its change. The $EBITDA_t$ is computed for each company over time as the sum of net profit, interest, taxes, depreceiation, and amortization. The dependent variables include revenue, R, total assets, A, total liabilities, L, total equity, E, total satellites launched to space, S, and endogenous time lags for each company. In other words, this work seeks models of the form

$$EBITDA_t = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \\ \beta_5 \\ \beta_6 \end{bmatrix}^\intercal \begin{bmatrix} EBITDA_{t-l-1} \\ R_{t-l} \\ A_{t-l} \\ L_{t-l} \\ E_{t-l} \\ S_{t-l} \end{bmatrix} + C, \quad (2)$$

where $\beta \in \boldsymbol{\beta}$ indicate the influence of each exogenous variable on $EBITDA_t$, $l \geq 0$ is the time-lagged variable, and C is a free scalar used to minimize the mean-squared error.

2.2 DuPont Analysis

While econometric analysis aims to build a model from tunable capital inputs to forecast future operations, it is also helpful to understand operations by examining how capital inputs are converted to one another. The DuPont analysis tracks operational indicators to examine how capital inputs and outputs to each company are converted [72]. These indicators are Financial Leverage (FL), Asset Turnover (AT), Net Profit Margin (NPM), and their multiplication gives the Return on Equity (RoE). The formulas for each indicator are shown in Eqns. (3-6).

$$FL = \frac{\text{Total Assets}}{\text{Total Equity}} \quad (3)$$

$$AT = \frac{\text{Revenue}}{\text{Total Assets}} \quad (4)$$

$$NPM = \frac{\text{Net Profit (Loss)}}{\text{Revenue}} \quad (5)$$

$$RoE = FL \times AT \times NPM \quad (6)$$

The FL measures solvency, indicating how reliant a company is on debt to finance assets. Most companies balance debt with equity to fund operations and growth. Solvency increases with FL. The AT measures efficiency, indicating how much of the assets are used to generate revenue. Efficiency increases with AT.

The NPM measures profitability, indicating how much profit the company earns for each dollar of revenue. Profitability increases with NPM, usually as a result of reducing production costs or increasing sales. The RoE combines FL, AT, and NPM to measure solvency, efficiency, and profitability. This metric indicates how effectively equity is used to generate profit. Improvement in FL, AT, or NPM improves RoE.

2.3 Interview Analysis

Four informational interviews were conducted with EO company executive officers representing iQPS, Synspective, Prométhée, and Planet Labs via video conference. Each interview followed the eight questions listed in Appendix A. The questions addressed challenges and opportunities in technology, business, growth, and risk management in commercial EO. All interviews were recorded and transcribed. The interviews were analyzed in two stages. The first stage involved analyzing responses on a per-company basis. Answers from each company were examined individually, starting with selecting themes in responses. A frequency analysis was performed to identify commonly used words across the answers. The second stage involved analyzing responses by question, cross-referencing answers from different companies. This comparative analysis aimed to outline general approaches and areas of disagreement on each topic.

3. Results and Discussion

Econometric analysis is performed on publicly-available time series data for five companies. An ARDL model is fit to the data for each company used to forecast $EBITDA_t$ and R_t (Section 3.1), and a DuPont analysis of the FL, AT, NPM, and RoE operational performance indicators is performed over time (Section 3.2). A cross-sectional analysis of four interviews of executives in the space industry is also performed (Section 3.3). Findings (Section 3.4) and limitations and opportunities for future work (Section 3.5) are discussed.

3.1 Econometric Analysis

The $EBITDA_t$ and R_t for iQPS, GOMSpace, Kleos Space, Planet Labs, and Satellogic were fit with ARDL models and the $EBITDA_t$ models are summarized in Eqns. (7–11). The between-variable correlations for the $EBITDA_t$ and R_t models are shown in Table 1 and Table 2, respectively. Positive (green) correlations indicate where growth in an exogenous variable leads to growth in the endogenous variable and where decline in an exogenous variable leads to decline in the endogenous variable. Negative (blue) correlations indicate where growth in an exogenous variable leads to decline in the endogenous variable and where decline in an exogenous variable leads to growth in the endogenous variable.

iQPS:

$$EBITDA_t = \begin{bmatrix} 5.378 \\ -62.42 \\ 62.39 \\ 60.60 \\ -262.6 \end{bmatrix}^\intercal \begin{bmatrix} R_t \\ A_t \\ L_t \\ E_t \\ S_t \end{bmatrix} + 8740 \tag{7}$$

GOMSpace:

$$EBITDA_t = \begin{bmatrix} -0.0196 \\ 1.895 \\ -55600 \\ 55600 \\ 55600 \\ -42830 \end{bmatrix}^\intercal \begin{bmatrix} EBITDA_{t-1} \\ R_t \\ A_t \\ L_t \\ E_t \\ S_t \end{bmatrix} - 2988000 \tag{8}$$

Kleos Space:

$$EBITDA_t = \begin{bmatrix} 0.0476 \\ -0.0629 \\ 5610 \\ -5610 \\ -5610 \\ -38050 \end{bmatrix}^\intercal \begin{bmatrix} EBITDA_{t-1} \\ R_t \\ A_t \\ L_t \\ E_t \\ S_t \end{bmatrix} - 3097000 \tag{9}$$

Planet Labs:

$$EBITDA_t = \begin{bmatrix} -1.806 \\ -7997000 \\ 7997000 \\ 7997000 \\ -138400 \end{bmatrix}^\intercal \begin{bmatrix} R_t \\ A_t \\ L_t \\ E_t \\ S_t \end{bmatrix} + 6703000 \tag{10}$$

Satellogic:

$$EBITDA_t = \begin{bmatrix} -3.551 \\ 1.588 \\ -1.462 \\ -1.806 \\ -0.0340 \end{bmatrix}^\intercal \begin{bmatrix} R_t \\ A_t \\ L_t \\ E_t \\ S_t \end{bmatrix} - 3260000 \tag{11}$$

The $EBITDA_t$ models for the currently-operational EO companies–iQPS, GOMSpace, Planet Labs, and Satellogic–all suggest total assets is positively correlated with revenue, while total liabilities and total equity are negatively correlated with revenue. The model for the inoperational EO company–Kleos

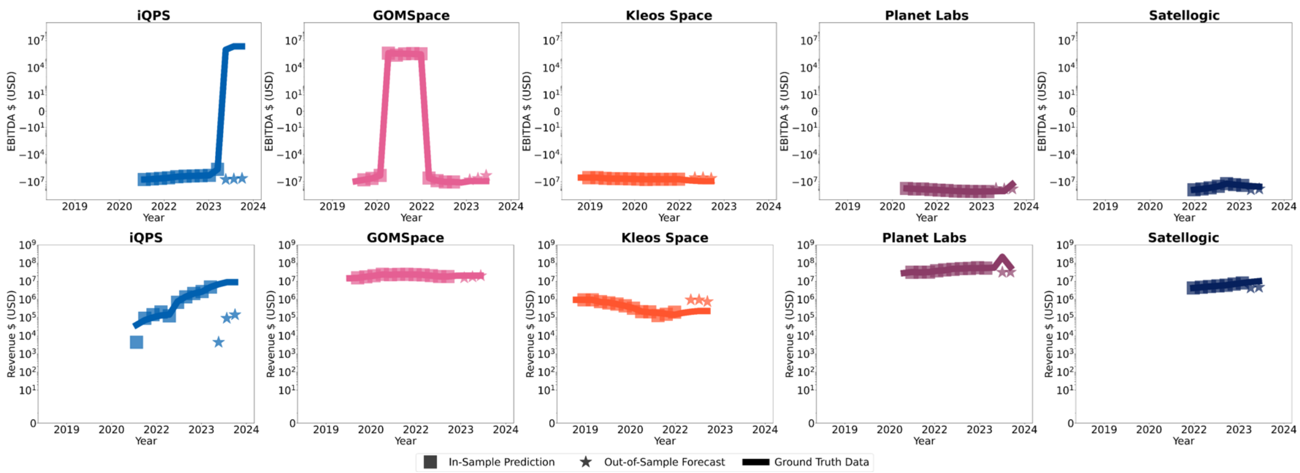

Figure 4: The EBITDA (top) and revenue (bottom) for each company is fit with an ARDL model. In-sample predictions indicate goodness of fit for each models, and out-of-sample predictions indicate robustness to forecasting future, unseen data. For the currently-operational companies–iQPS, GOMSpace, Planet Labs, and Satellogic–the models forecast lower future revenues than the ground truth. For the currently inoperational company–Kleos Space–the model forecasts higher future revenues than the ground truth. These results suggest a practice of underpromising and overdelivering on financial performance contributes to sustainable operation. For all companies except iQPS–where the dynamics of the test data are significantly different than the time series used for fitting–the ARDL model forecasts EBITDA and revenue close to the ground truth values.

Space–confirms this trend: its model indicates total assets are negatively correlated with revenue and total liabilities and total equity are positively correlated with revenue.

Table 1: Correlations with EBITDA

Predicting: $EBITDA_t$		iQPS	GOMSpace	Kleos Space	Planet Labs	Satellogic
EBITDA	$EBITDA_{t-1}$	NA	-	+	NA	NA
Revenue	R_t	+	+	-	-	-
Assets	A_t	-	-	+	-	+
Liabilities	L_t	+	+	-	+	-
Equity	E_t	+	+	-	+	-
Satellites	S_t	-	-	-	-	-

NA	No autocorrelation	+	Positive correlation with $EBITDA_t$	-	Negative correlation with $EBITDA_t$

Table 2: Correlations with Revenue

Predicting: R_t		iQPS	GOMSpace	Kleos Space	Planet Labs	Satellogic
Revenue	R_{t-1}	+	+	+	-	NA
Revenue	R_{t-2}	NA	-	+	NA	NA
Assets	A_t	+	+	-	+	+
Liabilities	L_t	-	-	+	-	-
Equity	E_t	-	-	+	-	-
Satellites	S_t	+	+	+	+	-

NA	No autocorrelation	+	Positive correlation with R_t	-	Negative correlation with R_t

As shown in Table 1 and Table 2, the negative correlation of assets with EBITDA and positive correlation of assets with revenue indicates a tension in EO business. It is expensive to invest in operating a satellite fleet (it negatively impacts earnings), and at the same time it is necessary to increase the value of the product (to increase revenue). The general negative correlation of satellites with EBITDA and positive correlation of satellites with revenue is evident for nearly every company to corroborate the industry trend. A second observation is debt, whether through equity or loans, is positively correlated with EBITDA and negatively correlated with revenue. This indicates how important the availability of external or borrowed capital is to reach commercial viability in EO. A final recognition is these two tables are approximately inversions of each other. Where one variable is positively correlated with revenue, it is negatively correlated with EBITDA. This is likely a feature unique to space hardware-developing EO startups since companies in this category require significant capital expenditure to reach the first customer. Enduring EO companies are expected to have matching EBITDA and revenue correlation tables once the technologies reach full productivity.

The in-sample predictions, out-of-sample forecasts, and ground truth predictions of $EBITDA_t$ and R_t using the fit ARDL models is shown in Figure 4. To validate the ARDL models, the first 90% of data in the time series is used for model fitting and the last 10% of data is used for forecasting. For the currently-operational companies, the models forecast lower future revenues than the ground truth. For the currently inoperational

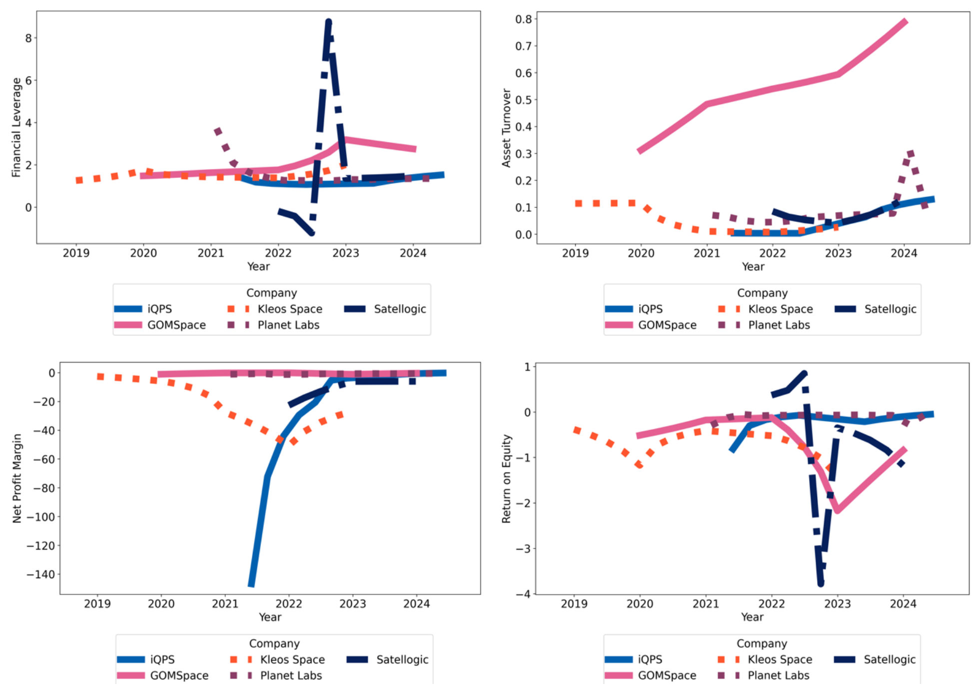

Figure 5: The DuPont analysis visualizes company solvency, efficiency, and profitability over time.

company, the model forecasts higher future revenues than the ground truth. These results suggest a practice of underpromising and overdelivering on financial performance contributes to sustainable operation. For all companies except iQPS–where the dynamics of the test data are significantly different than the time series used for fitting–the ARDL model forecasts EBITDA and revenue close to the ground truth values.

In this time-series econometrics analysis, operational companies exhibited similar correlation trends and the inoperational company followed the opposite trends. The ARDL models show high goodness-of-fits for in-sample prediction and out-of-sample forecasting. Models such as the ARDL model could help prospective EO investors and program managers estimate business health in terms of earnings and revenue given asset, liability, equity, and satellite time series data.

3.2 DuPont Analysis

A time-series DuPont analysis highlights the unique margins each company uses to achieve profitability. The FL, AT, NPM, and RoE over time for each of the five public companies is shown in Figure 5. All companies examined exhibit negative NPMs, reflecting high operational costs and investment needs exceeding revenue generation across the EO sector. However, apart from the Initial Public Offering (IPO) period, FL remains stable near 2%, indicating prudent financial management. Asset turnover is generally low, below 30%, except for GOMSpace.

GOMSpace demonstrates relatively stable financial health, supported by strategic geographic expansion and portfolio diversification, which has diversified its revenue streams over the last decade. Workforce rationalization strategies have enabled GOMSpace to control its assets effectively, mitigating the impact of temporary impairments while maintaining higher asset turnover relative to its peers [34].

Kleos Space encountered significant financial challenges, with revenue consistently declining since 2018. The 2022 annual report revealed substantial asset impairment, increasing net losses. The anticipated revenue of the company recovery following satellite launches did not materialize due to malfunctions, with one of its four clusters deemed inoperable as of August 2022. The remaining clusters incurred further impairments of approximately \$1.5 million in December 2022. One risk was the decision of the company to not insure its satellites, forcing it to absorb these losses directly. The lack of revenue during the pre-launch phase and

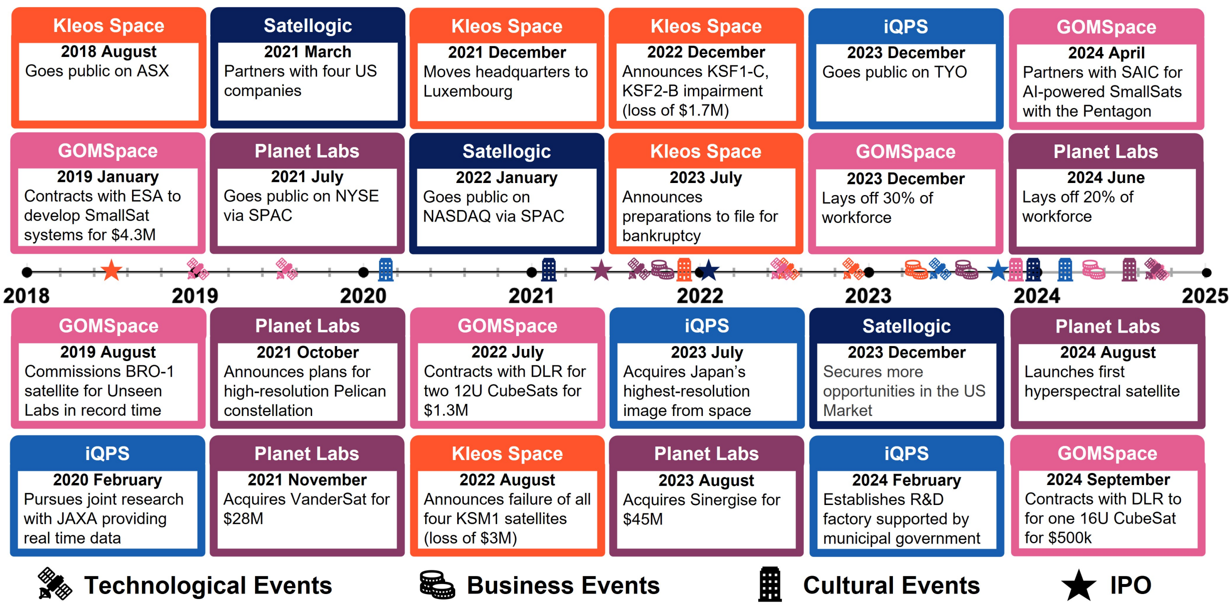

Figure 6: Company press releases are translated into milestones to contextualize peaks in financial performance with events in the business trajectory.

these impairments contributed to Kleos Space filing for bankruptcy in July 2023 [38].

iQPS achieved a positive EBITDA in May 2024, driven by launch and operations of its sixth satellite and increased revenue streams. The company is on track to further improve operational efficiency toward the production of QPS-SAR satellites in 2024. The technological advancements of iQPS continue to attract significant government contracts with over $100 million raised from various institutions to-date [73].

The 2022 IPO of Satellogic via Special-Purpose Acquisition Company (SPAC) added more than $150 million to its balance sheet and temporarily raised FL. The company is steadily pursuing market expansion in the U.S., and is expected to continue in earnest in 2024. With consistent revenue growth, Satellogic is positioned for leadership in this sector [57, 59].

Planet Labs grew by diversifying its satellite portfolio, making strategic acquisitions, and delivering higher-value processed data. The company expanded into hyperspectral imaging and began processing data onboard its satellites with AI, securing numerous contracts across multiple industries. By early 2024, Planet Labs acquired over 1,000 customers, demonstrating continued growth and strong financial standing [74, 75].

These major company events are further contextualized in Figure 6[4]. While these companies are advancing through product and customer expansion, IPOs, and technological developments, their financial sustainability remains uncertain. Satellite investments require substantial upfront capital and face business risks from delayed revenue generation and operational failures post-launch. Government customers may be the only institutions willing to accept this level of risk in the near term; government contracts are vital for stable revenue. Fundraising through IPO is effective, but it also exposes companies to greater scrutiny. A financial polarization is evident, with firms such as Planet Labs establishing solid foundations, while others, such as Kleos Space, face severe financial crises. Achieving profitability and long-term financial health will be critical to the future success or failure of these companies.

3.3 Interview Analysis

Interviews with four executives in the Earth Observation sector provided insights to cultural trends. Companies often establish market niches by capitalizing on emerging opportunities and new technologies. A notable trend is the transition toward increasing the value of data through post-processing. This leads to

[4] Events of each company were obtained through company-released financial reports and press releases [76, 77, 78, 79, 34, 80, 81, 82, 83, 84, 38, 85, 86, 87, 88, 89, 90, 91, 92, 93, 59, 94, 95].

increased revenues that can be reinvested into R&D, fostering further innovation. Additionally, offering new services facilitates the creation of new markets and attracts private investment. The monetization of data through the sale of processed information broadens the customer base and makes EO data accessible to non-expert users, further enhancing market growth. This shift toward selling actionable insights rather than raw data also increases awareness of EO data applications, attracting new clients and investments. Companies that prioritize analytics over payload technologies exemplify this approach.

One industry trend is toward calculated risk-taking. Risk-averse companies prefer adopting mature technologies with institutional funding or other commercial entities to avoid the high costs and risks associated with immature technologies. Returns on investment must justify expenses within an acceptable timeframe. Some companies mitigate risks by entering R&D agreements, offering technical expertise under contract. Additionally, successful firms may acquire competitors that failed due to market strategies, despite possessing sound technologies.

When approaching commercialization, the interviewed companies generally prioritize selling up-to-date data over payload technologies, with high-value data driving the business. Combining product- and service-based strategies is most effective, depending on company maturity and market strategy (e.g., MVP-based customer outreach, technological competitive advantage, integrated solutions). Selling processed data and services instead of raw data increases awareness of EO data applications, making remote sensing imagery more actionable and valuable. This attracts new customers and private investments.

Early-stage EO companies typically rely on institutional funding and support in the early stages to develop proprietary technologies and build credibility. Government and defense clients prioritize large-scale, rapid product deployment with strict performance requirements such as revisit time and resolution, which may not align with early-stage development. Contracts from governments often materialize during the growth phase. As a result, startups frequently use MVPs as their initial market entry to collect customer feedback and enhance credibility. Governments also regulate EO to ensure data sovereignty, remote sensing safety, and privacy in accordance with national laws. Companies must comply with these regulations to ensure market viability. Collaboration through partnership and expertise sharing among smaller EO companies gradually shifts the market away from the dominance of large prime contractors. Although vertical integration was not pursued by the companies interviewed, it is not deemed essential for success in this ecosystem.

The interviews reflect a consensus on the potential for EO market growth, driven by direct involvement of customers in shaping innovative, market-responsive services. While government and institutional clients remain main customers, there is a concerted effort to expand into the commercial market. This cross-sectional analysis supports the hypothesis that cultural innovation significantly impacts the commercial success of EO companies.

3.4 Discussion and Recommendations

The authors formulated a list of recommendations addressing business and cultural innovations, through cross correlating the quantitative financial analysis and the qualitative outcome of the conducted interviews reported in this paper.

In business innovation, strategic institutional partnerships improve credibility and help secure the R&D funding instrumental to attract private investments. These alliances position EO companies for future government contracts once production capabilities are in place. Aligning revenue forecasts with asset levels and setting realistic profitability timelines are crucial for sustainable growth. Effective financial risk management during scaling requires synchronized capital expenditure and financial coverage, with comprehensive insurance to cover operational failures. Diversifying product offerings and expanding into international markets can help improving the financial stability.

Scaling operations must be carefully timed and financially supported, particularly in capital-intensive areas like satellite manufacturing, where delayed revenue recovery is common. Premature expansion without a solid customer base can lead to financial instability. Operational failures can result in significant deficits, underscoring the importance of insurance and lean production processes. Market shifts, SPAC & IPO, mergers, and positive financial indicators such as EBITDA highlight the importance of financial agility and technological innovation, including AI integration.

Early MVP launches enable rapid feedback, refine technologies, and accelerate revenue generation. This approach reduces dependence on continuous funding rounds by generating early contracts and minimizing operational risks. Companies should also focus on monetization, actively seeking revenue growth to strengthen their financial position. Acquiring talent and expertise through strategic mergers or by hiring experienced professionals from within the EO industry allows companies to expand capabilities while controlling costs.

In-house value-added services offers cost advantages and greater control over product customization, particularly in case of vertical integration, enhancing engagement with high-value customers. This internal approach ensures tailored solutions, increasing profitability. Diversifying beyond traditional satellite data sales and engaging with users expands revenue streams and strengthens market resilience. Competing directly with tech giants and established primes is a losing battle; success lies in disrupting the game, the target, or the rules. A service-based model, supported by competitive pricing, advanced services, and customer care, helps companies grow and stabilize their user base, as demonstrated by industry leaders like Starlink, Amazon, Google and more.

In cultural innovation, new technologies require careful consideration of their market impact, especially when disrupting existing processes. Companies should develop both short- and long-term plans for Agile product development, balancing market timing with risks. Commensurate risk management should be set in place to mitigate internal inefficiencies and external challenges such as market volatility and regulatory shifts. Using qualified technologies, managing risks, and insurance help limit financial exposure and reputation damage when failure inevitably occurs. Strategic partnerships play a vital role in accelerating market entry and technological development. A robust marketing department drives decision-making and promotes customer acquisition. Active engagement within the EO community and staying informed about industry trends is crucial for development. Participation in conferences and events with industry enables companies to establish valuable relationships, stay up-to-date on emerging technologies, and identify new market opportunities.

Customer relationship is critical for increasing the number of users and the service utilization. To enhance service offerings, companies should provide training that helps users understand and fully benefit of advanced services, including analytics, predictive modeling, and real-time data integration. Ensuring clients are informed about the value of these novel services will improve customer engagement and strengthen market positioning. Offering processed data and value-added services rather than raw data expands customer awareness of EO applications, attracting new customers and investments, as evidenced by companies focusing on analytical solutions over payload technologies.

3.5 Limitations and Future Work

The econometric analysis examined data from five public companies selected to represent geographic diversity in their headquarters, aiming to capture global rather than regional trends. However, the small sample size makes it challenging to discern whether a company is an outlier or whether regional differences are insufficiently reflected in the global analysis.

It is difficult to attribute the financial performance to a single event or metric. While major events such as market shifts, acquisitions, or layoffs are likely to influence financial indicators, this analysis does not include cash flow statements or equity costs, limiting its depth. Future studies could refine the analysis by incorporating a broader range of metrics and data types.

The company selection was limited to startups focused on the EO sector. While insights from startups are valuable, the EO sector is significantly shaped by larger conglomerates such as Airbus and Thales, whose financial metrics differ from those of startups. Despite detailed financial reports, it remains difficult to separate corporate resources allocated to specific services, as departments like operations and HR are often distributed across all divisions.

Finally, questions remain about the suitability of the selected metrics (revenue, assets, liabilities, equity, and satellite count) in accurately assessing business performance. Financial metrics alone may not fully capture the dynamics of technology startups, where R&D investments take time to yield returns. This may explain why all companies in this study reported negative net profit margins. Additionally, the number of satellites may not provide insights comparable to financial figures, as different constellations serve different purposes. For instance, Planet Labs operates high-saturation, low-cost satellites with frequent replacement, whereas other companies deploy more expensive satellites with longer lifespans.

While financial figures may have some level of subjectivity, interviews introduce more opportunities for bias, with company representatives often emphasizing positive aspects and minimizing challenges. Ideally, the same set of questions should be posed to both successful and unsuccessful companies, allowing for comparative analysis, but it is difficult to contact former executives of unsuccessful or dissolved companies. Future research could benefit from a broader market analysis that includes more EO startups from a variety of operational stages. This would enable a comparison of trends between successful public and private companies and provide a more comprehensive understanding of the EO market. Additionally, increasing the number of interviews could allow for word-based analysis, enhancing the qualitative insights. Extending these methods to other space markets, such as telecommunications or launch vehicles, could further broaden the applicability of the findings.

4. Conclusion

This work analyzes business innovation cultures and trends within the commercial EO sector. A time-series econometric analysis and a DuPont analysis of financial data revealed trends in how five global EO companies operate. Interviews with industry executives from four global EO companies offered qualitative insights, enabling a multi-faced understanding of the strategic approaches used by currently-operational companies.

The findings indicate patterns contributing to business success in the EO market. Companies promoting their culture to push innovation in both technology and business models, maintaining strong risk management strategies, and fostering strategic partnerships tend to outperform their peers. The objective of startups should therefore not be making money, but rather de-risking their products, business thesis, and growth. Once scaled, profits will follow. The integration of Minimum Viable Products, early monetization, and a balanced focus on product-centric and service-based models emerged as critical drivers of growth.

Innovation is not only about technology, but also the value it creates. The correlation between quantitative and qualitative indicators further underscores the importance of aligning financial strategies with market trends, technological advancements, and customer expectations. Best practices such as the adoption of advanced analytics and AI, diversification of product offerings, and efficient scaling of operations influence commercial outcomes in EO.

Finally, this work serves as a foundation for future research into the business performance of space companies. The global space industry is rapidly commercializing: government partners, investors and business operators will increasingly aim to localize and mitigate inefficiencies in company culture and financing. The insights shared in work can guide these space industry stakeholders in navigating the evolving commercial EO landscape to achieve long-term commercial viability.

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Appendix

A. Interview Questions

The below questions were asked in the executive interviews.

1. Can you provide examples of innovative products, services, or business models your company has introduced to the EO market? Are there any products spinned in from other sectors?
2. How important is the definition of Minimum Viable Product and how did you approach its development?
3. How does your company adopt new technologies and innovations? What guides these decisions?
4. What are the benefits and drawbacks of product-centric versus service-based business models in terms of innovation and commercialization success in your perspective?
5. Which difficulties might your company face for scaling up in the EO sector? Any particular thoughts relatively to the financing culture and customer acquisition?
6. What approach is your company following in terms of risk-management and how important do you think this aspect is for a successful commercialization?
7. Are there specific new EO opportunities your company is exploring? If so, why have they not been pursued yet? What are the blocking points?
8. For young professionals entering the space sector, what advice would you offer for fostering innovation? For program managers, what advice would you give for incorporating innovation into established companies?

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Note from Authors

In 2023-2024, we participated in the IAF International Programme and Project Management Committee Young Professionals Workshop, a year-long program facilitating international cooperation among young space professionals to bridge the inter-geographical and inter-generational gap in the space industry.

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Spingerci più in là dei traguardi che ieri mai avremmo immaginato.

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Collaboration is innovation.

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11ヶ月間共に駆け抜けた仲間へ、心から敬意と感謝の意を表します。

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"Any technological advance can be dangerous. Fire was dangerous from the start, and so (even more so) was speech...but human beings would not be human without them." - I. Asimov

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