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Economic Indices: An Analysis of the Space Industry

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Abstract **–** The goal of this report is to analyze available information on economic conditions in the space exploration industry and obtain the information that would be necessary to create a measurement of growth relative to other industries. To accomplish this effectively, a thorough understanding of existing indices would be essential. Indices measure economic change, using calculations which aggregate a vast amount of information into one quantity. Many industries have their own indices which provide information about changes in business conditions. The indices chosen to study for this report are the Institute of Supply Management's Manufacturing Index and the Federal Reserve's Industrial Production Index. The Kensho New Economies Space Index (KMARS), a newly-formed index that tracks stock prices of companies involved in space commerce, is also examined to shed light on the industry. Four firms in the space industry are examined – Aerojet Rocketdyne, Boeing, Lockheed Martin, and Northrop Grumman – to determine the types of economic data available at a firm level.

I. Introduction

An index number aggregates a vast amount of information into a single quantity. These numbers are useful for analyzing changes in data collected on one or more variables over time (called a time series analysis), especially in macroeconomics (Woolridge, 2013). A basic example of an index is the consumer price index (CPI). The CPI is a measure of the level of prices. It is measured by showing the price of a bundle of goods relative to the same bundle of goods in a base year (Mankiw, 2010). To construct an index, a base period and base value need to be established. The base period and value are what each subsequent period and value are compared to in a time series analysis. Time series analyses are used to determine the effect an independent variable x has on a dependent variable y. In a time series, the value of the dependent variable in one period is correlated with its value in the next period. This is known as serial correlation or autocorrelation (Stock & Watson, 2014).

Three indices are examined in this report: the ISM Manufacturing Index, the Federal Reserve Industrial Production Index, and the Kensho New Economies Space Index. Research was conducted on these three indices and their relative industries to determine what the indices reveal about their industries, the methodology by which they are constructed, and what can be learned from them. The Manufacturing Index and the Industrial Production Index provide information on macroeconomic data such as company revenues and employment, while the Kensho Space Index is a stock market index. The long-term goal of this research project is to construct a space index that answers macroeconomic questions about the space industry which the Kensho space index fails to answer, to determine that the manufacturing index and the industrial production index sufficiently answer these questions about their respective industries, and to also determine the relevant information that is needed to answer these questions for the space industry.

II. The ISM Manufacturing Index

Manufacturing is the large-scale production of goods, using labor and machinery, to be sold to customers for use. It can involve the mechanical, physical, or chemical transformation of materials into new products intended for consumption or for use as capital. There are many subsectors of the manufacturing sector, including, but not limited to: food manufacturing, textile products, apparel manufacturing, paper manufacturing, wood product manufacturing, chemical manufacturing, computer and electronic product manufacturing, transportation equipment manufacturing, furniture manufacturing, and miscellaneous manufacturing. Establishments in the manufacturing industry include plants, factories, and mills, but products made by hand or in the home may also be included in this industry (U.S. Bureau of Labor Statistics, 2017).

The Institute for Supply Management (ISM) has constructed a manufacturing index, which observes employment, production, inventories, new orders, and supplier deliveries of over 300 manufacturing firms. This index reflects economic conditions in the U.S., and it serves as a signal to investors about changes in the industry. The index provides adequate information about business conditions in the manufacturing industry to supply management professionals, economists, analysts, and government and business leaders. The ISM surveys production and supply management firms nationwide and uses the data collected to construct its manufacturing index. Executives of the firms respond anonymously to a monthly questionnaire about changes in production, new orders, new export orders, imports, employment, inventories, prices, lead times, and the timelines of supplier deliveries, comparing the current month to the previous month. The survey also asks for data on commodities and remarks on current business conditions (The Institute for Supply Management, n.d.).

The Institute issues a monthly report on economic activity in the manufacturing industry. On November 1, 2017, it reported an overall expansion in the month of October. The report stated that new orders, employment, production, and backlog of orders continued to grow, while supplier deliveries slowed down. The industry saw a contraction of raw materials' inventories, and customers' inventories were too low (Cahill, 2017). A monthly series was constructed, showing trends in the manufacturing index from 1948 to 2017. The grey shaded areas represent periods of recession, and the red dots represent months leading to recessions (see **Fig. 1**).

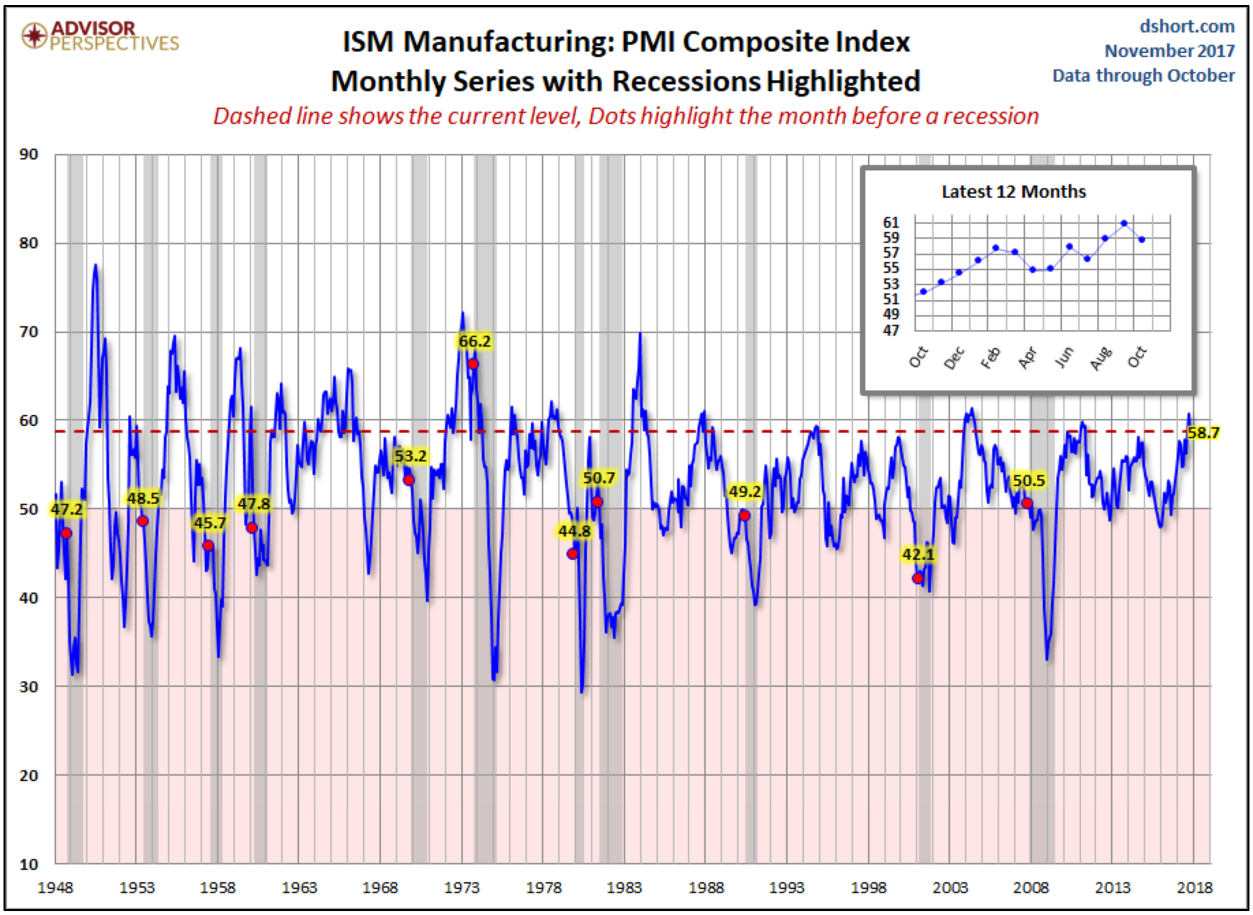

Fig. 1: *Advisor Perspectives. (2017, November). ISM Manufacturing: PMI Composite Index [Chart]. In Advisor Perspectives. Retrieved from www.advisorperspectives.com/images/content_image/data/b2/b27c392429e2f6dfe67c8058ffdf57d1.png*

II. Federal Reserve Industrial Production Index

The Board of Governors of the Federal Reserve releases monthly indices on industrial production and capacity utilization which cover manufacturing, mining, and electric and gas utilities. The industrial production sector, including construction, accounts for much of the national output throughout the business cycle. The industrial production index measures real output as a percentage of real output in a base year, which is currently 2012 (Board of Governors of the Federal Reserve System, 2017, October 12). It is constructed from 299 individual series, classified as market groups and industry groups, based on the 2012 NAICS codes. Market groups are made up of products and materials. Industry groups consist of three-digit NAICS industries and aggregates of those industries. Examples of three-digit NAICS industries are durable and nondurable manufacturing, mining, and utilities. The data for the industrial production index consists of two main types of source data: output measured in physical units (physical product) and inputs to the production process which result in physical output (production-worker hours). To aggregate the IP index, a version of the Fisher-ideal index formula is used. The formula for the monthly growth in industrial production, shown in **Fig. 2**, uses the unit value-added estimate for the current month (p_m) and the estimate for the previous month. The industrial production proportions are estimates of each industry's relative contribution to growth in the following year (Board of Governors of the Federal Reserve System, 2017, March 31). **Fig. 3** shows the trend in the Industrial Production Index from 1919 to 2017, the grey shaded areas indicating periods of recession. The index level falls during recessions and rises following these recessions as business activity picks up.

$$\frac{I^A_m}{I^A_{m-1}} = \sqrt{\frac{\sum I_m p_{m-1}}{\sum I_{m-1} p_{m-1}} \times \frac{\sum I_m p_m}{\sum I_{m-1} p_m}}$$

Fig. 2: *Board of Governors of the Federal Reserve System. (2017, March 31). Formula for Growth in Monthly IP [Image]. Retrieved from https://www.federalreserve.gov/releases/g17/explnote_g17.gif*

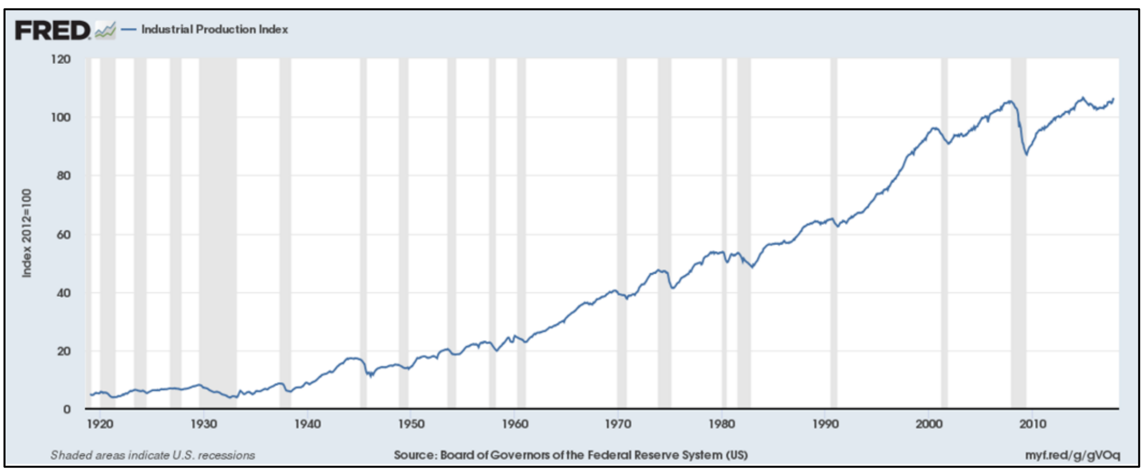

Fig. 3: *Federal Reserve Bank of St. Louis. (2017, December 15). Industrial Production Index [Chart]. Retrieved from https://fred.stlouisfed.org/series/INDPRO*

III. The Space Industry

The space economy is defined as the activities and use of resources involved in exploring, researching, understanding, managing, and utilizing space for the benefit of mankind (Space Safety Magazine, 2014). The global space activity in 2015 totaled $322.94 billion. Of that amount, $126.33 billion (39%) went toward commercial space products and services; $120.09 billion (37%) toward commercial infrastructure and support industries; $44.57 billion (14%) toward US government space budgets; and $31.95 billion (10%) toward non-US government space budgets (see **Fig. 4.**) (Space Foundation, 2016). According to the 2016 Space Report from the Space Foundation, the global space economy grew in 2015. Revenues from commercial sectors comprised more than three-quarters of all global economic space activity. Commercial space products and services, the largest sector, grew by 3.7% to $126.33 billion in 2015. Commercial infrastructure and support industries decreased 5.2% to $120.88 billion. This decline is mostly attributed to global navigation satellite system (GNSS) receivers which were subject to change in currency exchange rates. Global government spending also decreased by 4.8%. US government spending actually increased by 3.2%, while non-US government spending decreased. However, this decline was mostly due to exchange rates. In reality, most governments actually increased spending in the space economy (Space Foundation, 2016). The US employment outlook for the space industry is mixed. In 2014, the U.S. civil and commercial space workforce consisted of 221,585 workers, making it one of the largest in the world. However, it was contracting during this time, while employment in Europe and Japan increased. Future growth is expected for scientific disciplines such as astronomy, but a decline is expected in the demand for aerospace engineers. Demand for non-aerospace disciplines in the space industry, such as programmers, computer scientists, and data analysts is expected to increase in the near future (Space Foundation, 2016). Investment in space infrastructure is continuing to expand around the world. At least 19 countries are hosting or planning to host spaceports for orbital and suborbital launches. In 2015, 86 orbital launches were attempted around the world, which is the highest number in two decades. Two US companies, Blue Origin and SpaceX, successfully landed rockets that returned from space, the most significant development for the space launch industry. The number of large spacecraft being sent into orbit each year has remained relatively constant. Interest in the launch of small satellites has continued to grow. In 2015, nanosatellites made up 48% of the 262 spacecraft launched. However, they made up less than 1% of the total mass sent up into orbit in 2015. Telecommunications satellites made up 41% of the total mass. These satellites generate over $100 billion each year (Space Foundation, 2016).

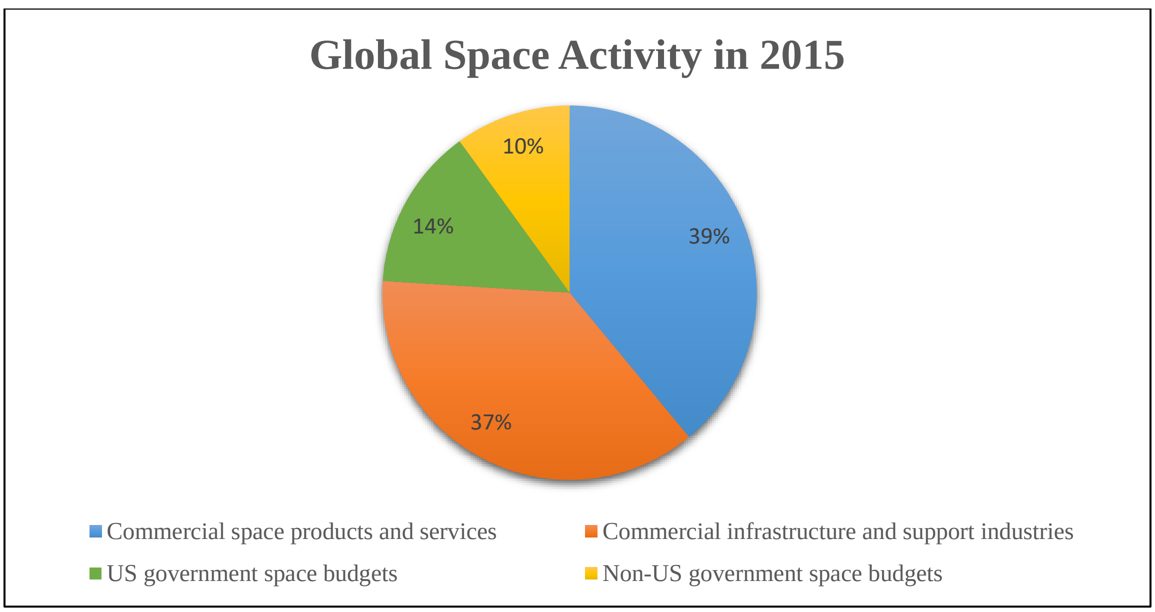

Fig. 4: *Space Foundation. (2016). [Pie chart showing make-up of global space activity in 2015]. The Space Report 2016: The Authoritative Guide to Global Space Activity (Rep.). Retrieved from https://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2016_OVERVIEW.pdf*

To obtain more information on the space industry, data was collected on a sample of four companies: Aerojet Rocketdyne, Boeing, Lockheed Martin, and Northrop Grumman. These four companies dominate the space industry in terms of employment and revenues. The following data reflects non-space manufacturing in addition to space manufacturing – the two could not be separated for this report. The reason for this is that some manufactured parts may be used in either rockets or airplanes.

Aerojet Rocketdyne is a major manufacturer in aerospace and defense. The company has seen a steady rise in total revenues, with a 9.9% increase from 2014 to 2016. From 2014 to 2015, there was a 6.6% increase, and from 2015 to 2016, there was a 3.1% increase (see **Fig. 5.**). Data was also retrieved on Aerojet Rocketdyne's employment history. Since 1989, employment has fluctuated but decreased overall. In 2004, employment decreased by 71.5%, though the reason for such a dramatic decrease was not found. From 1989 to 2016, there was an overall 66.7% decrease in the number of employees (see **Fig. 6.**).

Boeing is a large aerospace company which manufactures commercial airplanes and defense, space, and security products and systems. Boeing saw a 5.9% increase in revenues from 2014 to 2015. However, the firm had a decrease in total revenues of 1.6% from 2015 to 2016. The total change in revenues from 2014 to 2016 was 4.2% (see **Fig. 5.**). Boeing employment has decreased over the years. From 2000 to 2016, total employment decreased 24% (see **Fig. 6.**).

Lockheed Martin is a research, development, and manufacturing company in aerospace, defense, and security. From 2014 to 2015, the company saw a small, insignificant increase in revenues. However, from 2015 to 2016, the company had a spike in revenues of 16.6%. Total revenues from 2014 to 2016 increased by 18.3% (see **Fig. 5.**). Total employment in 2016 was 25.5% higher than in 1994. However, employment more than doubled from 1994 to 1995. From 1995 to 2016, employment decreased by 39.4% (see **Fig. 6.**).

Northrop Grumman is another major aerospace and defense company. The company's revenues dropped by 1.9% from 2014 to 2015, but rose by 4.2% from 2015 to 2016. Total revenues increased by 2.2% from 2014 to 2016 (see **Fig. 5.**). While the other three companies saw decreases in employment over the years, Northrop Grumman had an overall increase in employment by 58.5% from 1989 to 2016 (see **Fig. 6.)**. In **Fig. 6**, the trends in employment of the four companies from 2000 to 2016 are shown. A general decrease in employment can be seen following the 2008 recession.

Of the four companies researched, three are members of the Satellite Industry Association (SIA): Boeing, Lockheed Martin, and Northrop Grumman. The SIA releases an annual report on satellite industry data analyses. **Table 1** contains the total revenues of the global satellite industry in the past three years, as well as the total employment in the third quarter of 2016. The revenues of the three companies combined comprise about 6% of the total satellite industry revenues (see **Table 2.)**.

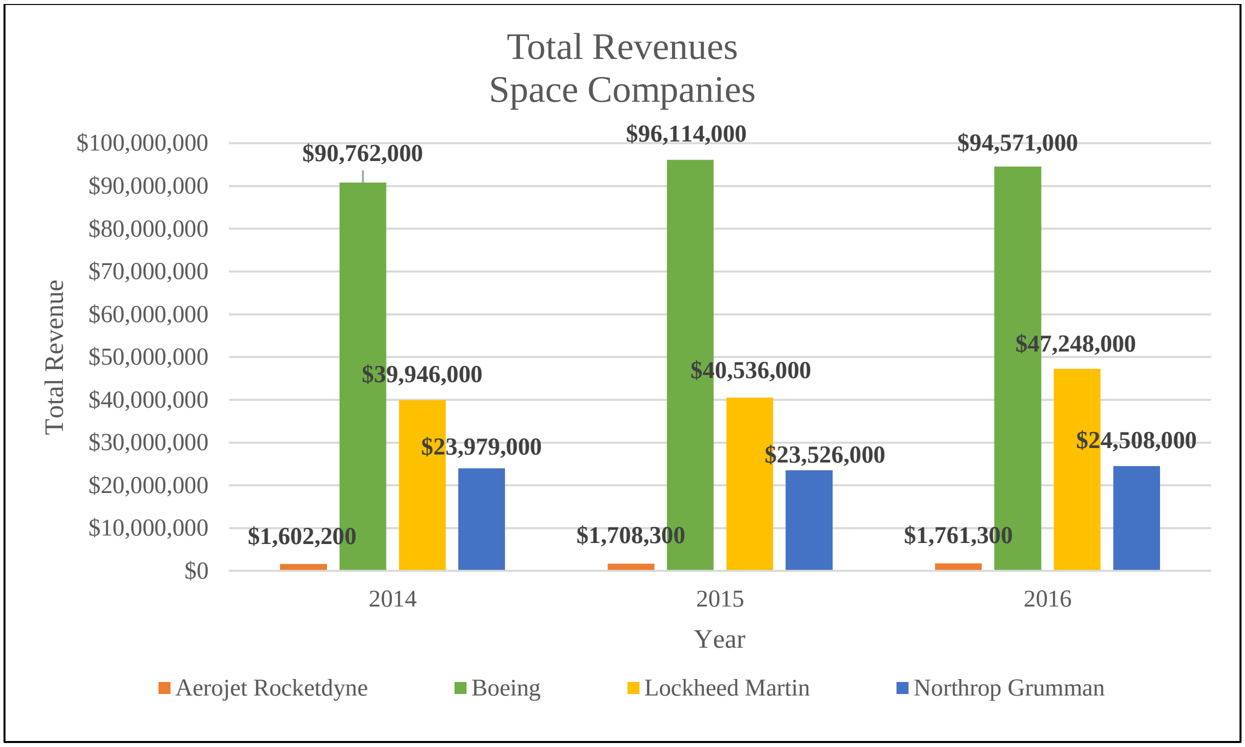

Fig. 5: *Total revenues for space companies in 2014-2016. Data retrieved from Yahoo! Finance.*

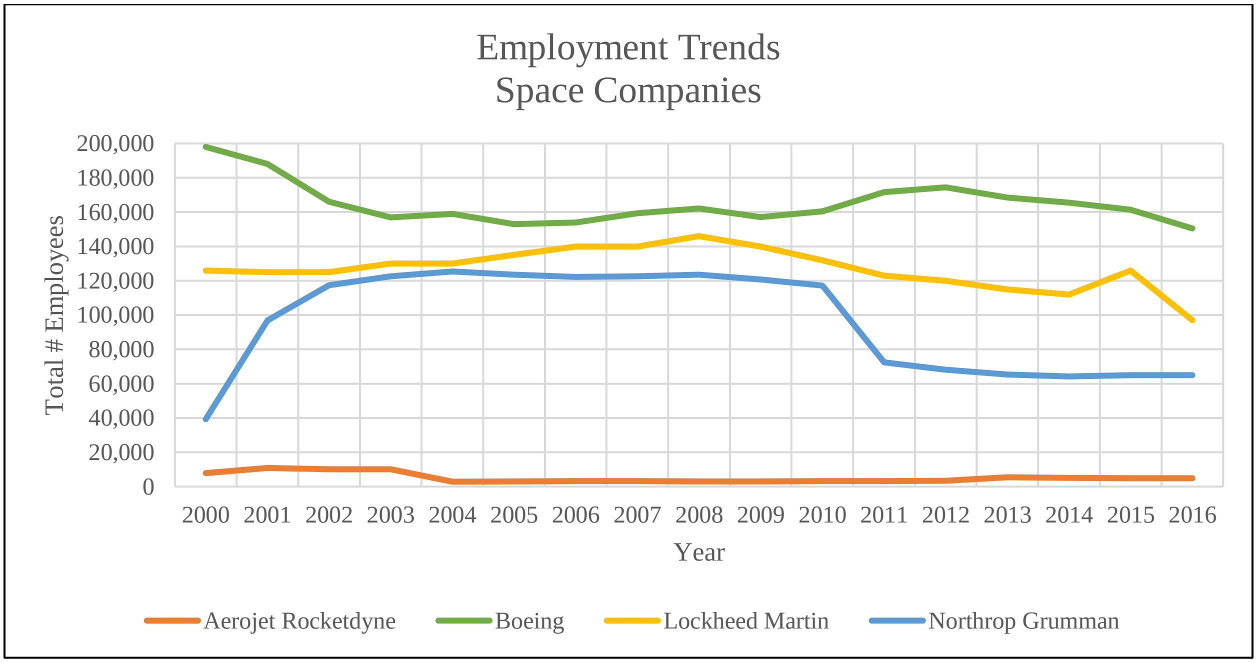

Fig. 6: *Trends in Employment for Space Companies from 2000 to 2016. Data retrieved from Morningstar database.*

INDUSTRY	YEAR	REVENUES (IN BILLIONS)	EMPLOYMENT (3Q 2016)
GLOBAL SATELLITE INDUSTRY	2016	$261	211,185
	2015	$255	
	2014	$247	

Table 1: *Satellite Industry Association. (2017, June). [Table showing total revenues for 2014 – 2016 and total employment in the third quarter of 2016 in the global satellite industry]. State of the Satellite Industry Report 2017 (Rep.). Retrieved from http://www.sia.org/wp-content/uploads/2017/07/SIA-SSIR-2017.pdf*

COMPANY	YEAR	REVENUES	DIFFERENCE	PERCENTAGE
BOEING	2016	$ 94,571,000	$260,905,429,000	3.6234%
	2015	$ 96,114,000	$254,903,886,000	3.7692%
	2014	$ 90,762,000	$246,909,238,000	3.6746%
LOCKHEED MARTIN	2016	$ 47,248,000	$260,952,752,000	1.8103%
	2015	$ 40,536,000	$254,959,464,000	1.5896%
	2014	$ 39,946,000	$246,960,054,000	1.6172%
NORTHROP GRUMMAN	2016	$ 24,508,000	$260,975,492,000	0.9390%
	2015	$ 23,526,000	$254,976,474,000	0.9226%
	2014	$ 23,979,000	$246,976,021,000	0.9708%
ALL 3	**2016**	**$ 166,327,000**	**$260,833,673,000**	**6.3727%**
	2015	**$ 160,176,000**	**$254,839,824,000**	**6.2814%**
	2014	**$ 154,687,000**	**$246,845,313,000**	**6.2626%**

Table 2: *Satellite Industry Association. (2017, June). [Table showing total revenues of three companies as percentage of total revenues of the global satellite industry]. State of the Satellite Industry Report 2017 (Rep.). Retrieved from http://www.sia.org/wp-content/uploads/2017/07/SIA-SSIR-2017.pdf*

IV. Kensho New Economies Space Index

The Kensho Space Index (KMARS) is one of the New Economies indices released by Kensho Technologies, a data analytics and machine intelligence company. It is a stock index that captures 30 companies in the space sector, including the four companies observed for this report. The companies included in the index focus on space exploration and building rockets, launch vehicles, and satellites (CNBC, 2016). Only companies with a market capitalization of at least $300 million and a three-month Average Daily Traded Value (ADTV) of at least $2 million are eligible to be included in the Kensho Space Index (Kensho Technologies, Inc., 2016). The historical performance of KMARS from July 2013 to December 2017 is shown in **Fig. 7**, with the month and year in the x-axis and the index level in the y-axis.

The Index is based on the initial value of 100 at the close of trading on May 15, 2013, the start date. The Index level is calculated with the formula:

$$level_t = \frac{\sum(x_{i,t} \cdot p_{i,t} \cdot f_{i,t})}{D_t}$$

In this formula, $x_{i,t}$ is the number of index shares of the Index Component[1] i on Business Day[2] t; $p_{i,t}$ is the trading price of Index Component i on Business Day t; $f_{i,t}$ is the foreign exchange rate to convert the price of Index Component i on Business Day t into the Index Currency[3]; and D_t is the Divisor on Business Day t. The Divisor on the start date is calculated with the formula:

$$D_t = \frac{\sum(x_{i,t} \cdot p_{i,t} \cdot f_{i,t})}{100}$$

The Divisor at the close of trading on an Adjustment Day t is calculated with the formula:

$$D_t = \frac{\sum(x_{i,t} \cdot p_{i,t} \cdot f_{i,t})}{level_t}$$

The level of the Index calculations, the trade prices, the foreign exchange rates, and the Divisors all must be rounded to six decimal places. The accuracy of the Index calculations is subject to these constraints. Adjustments to the Index are required for systematic changes in prices, requiring that the new Number of Index Shares[4] of the affected Index Component and the Divisor be calculated on an ex-ante[5] basis (Kensho Technologies, Inc., 2017).

The goal of the index is to track the companies that focus on products and services to further enable space travel and exploration (Kensho Technologies, Inc., 2017). While this index sheds some light on the space industry, it is lacking information, such as employment, revenues, production, etc., that is present in the ISM Manufacturing Index and the Federal Reserve Industrial Production Index.

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[1] An "Index Component" is a share that is currently included in the Index (Kensho Technologies, Inc., 2017).
[2] A "Business Day" is a day on which the NYSE is open for trading (Kensho Technologies, Inc., 2017).
[3] "Index Currency" is USD (Kensho Technologies, Inc., 2017).
[4] The "Number of Shares" of an Index Component on a given Business Day is the number or fraction of shares included in the Index. It is calculated as the ratio of the Percentage Weight (the ratio of the Trading Price multiplied by the Number of Shares divided by the Index value) of an Index Component multiplied by the Index values, and its Trading Price (Kensho Technologies, Inc., 2017).
[5] "Ex-ante" is a term that refers to future or forecasted events.

Fig. 7: *Solactive. (2017, December 15). Kensho Space Index GTR: Historical Performance [Chart]. Retrieved December 18, 2017 from https://www.solactive.com/wp-content/uploads/solactiveip/en/Factsheet_DE000SLA1G71.pdf*

V. Conclusions and Future Directions

The ISM Manufacturing Index and the Federal Reserve Industrial Production Index provide information about the business activities such as production, employment, inventories, real output, and more in their respective industries. These indices show how business performances have grown or declined over time. This information is vital to investors who need to know the business conditions of the companies and industries in which they are investing. It is also useful for forecasting future trends. The Kensho New Economies space index, while it provides useful information about the space industry to stockholders, does not adequately capture the information on the space industry that the manufacturing and industrial production indices capture on their industries. To combat this lack of information, an index for the space industry that includes variables such as employment, revenues, production, etc. should be created. The data collected on the space industry so far, included in this report, shows that there is a vast amount of information that can be compiled to calculate such an index. Larger databases such as Bloomberg or Morningstar will provide access to relevant information. Time series analyses can be conducted to observe trends in the economic activity of space companies, and the variables affecting changes in the industry can be determined. A base period can be established, and by using an index such as the Fisher-ideal index, future activities can be compared. This will give the user of the index a snapshot of how the industry has performed over time. The Kensho index, while useful, is narrowly focused to assist traders in determining the value of space companies in terms of financial investment. An index like the ISM Manufacturing Index and the Industrial Production Index is much broader, encompassing an entire sector of the economy. An index that tracks space-related economic activities would be a useful index because it will allow us to gauge space activity within the context of the whole economy.

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