Feasibility Analysis of Widening Panama Canal Based on Polynomial Regression

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Abstract

The panama canal is one of the most important waterways in the world, because of the large ship, the original channel capacity is limited, not only the expansion of the panama canal in 2016, and opened the third set of locks, make capacity greatly improve, using polynomial regression model, after fitting error is small, compared the ship through the panama canal is predicted and the actual value on average, has carried on the feasibility analysis to the panama canal, the analysis shows that the panama canal to broaden and by ship for the people of panama, and even the world shipping brought quite a positive impact.

Keywords

Panama Canal; Polynomial regression;Broaden;Traffic capacity.

1. Reasons for Expansion

1.1. Geographical Features of the Panama Canal

The panama canal crosses the isthmus of panama and connects the Pacific and Atlantic oceans. It is one of the most important shipping lanes in the world. It is not only known as the "bridge of the world", which is one of the seven engineering wonders of the world, but also one of the world's two grand canals of strategic significance with the Suez Canal.

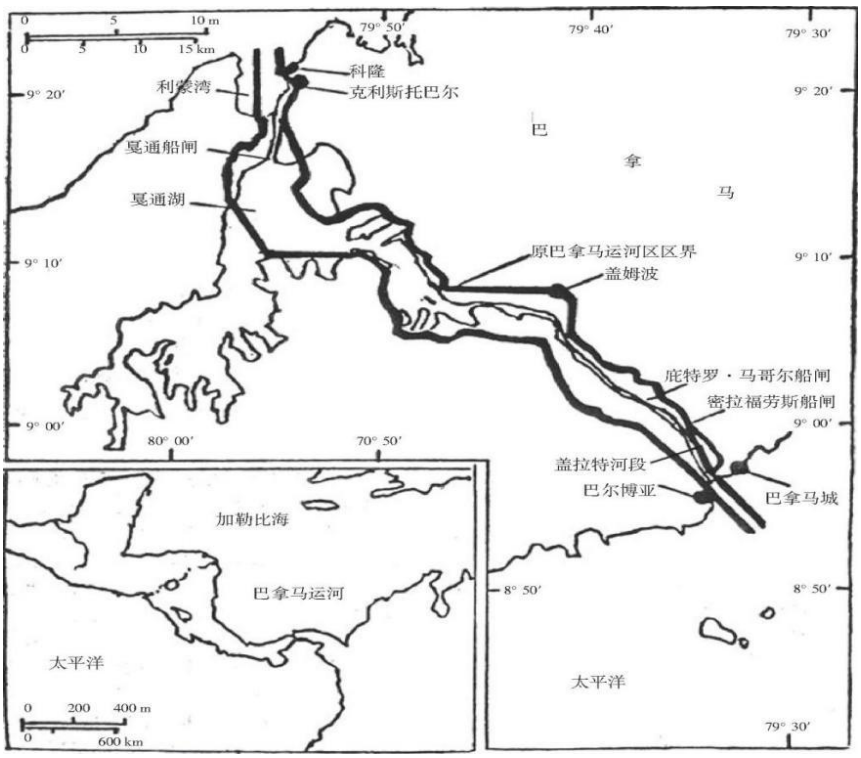

Figure 1. Outline of Panama Canal

At its narrowest point, the isthmus of panama is 300 metres wide and 91 metres at its narrowest.When locks are already built to adjust the difference in water levels, the panama canal should also be considered for the passage of larger and more ships.Each end of the panama canal was built with three levels of upgraded locks and supporting facilities, while a new type of waterway, the serpentine channel, was widened and deepened to make way for the new locks on the Pacific side.

1.2. The Status of the Panama Canal Before Its Expansion

1.2.1. Longer Maintenance Time

Since the opening of the panama canal, due to the aging of the facilities and equipment, the current two lock systems need regular maintenance, and the maintenance time increases year by year with the deepening aging of the facilities.The lock needs to be temporarily closed during maintenance, causing congestion.The temporary closure cut shipping traffic through the panama canal by 30 percent.In the five years since 2000, the panama canal has had to be temporarily closed at least five times a year, with each maintenance period of about 11 days.That leaves hundreds of ships stranded every year.The phenomenon of ships queuing to cross the river is becoming more serious, especially for small and medium-sized customers who are affected by the temporary closure. On the one hand, the cost is greatly increased, and on the other hand, the water transport work cannot be completed as scheduled.

1.2.2. The Upsizing Trend of Ships Is Obvious

With the increase of the workload of water transport, the demand for upsized ships is increasing.Today, 150 trade routes are designed to pass through the canal, and ships of all shapes and sizes pass through the panama canal, with the number of larger ships increasing year by year.According to statistics, the width of nearly 45% of the ships crossing the river is close to the allowable limit of the lock, and the length of 10% of the ships is close to the allowable limit of the ship. As we all know, when the ships crossing the river reach a certain limit, it will take more time, which to a large extent causes the increase of transportation cost and the subsequent increase of the ship detention rate.

1.2.3. Canal Capacity Is Close to Its Limit

Based on reliable model actuarial calculations, the maximum capacity of the existing canal is between 330 and 340 million tons per year.The panama canal had a tonnage of 280 million tons in 2005.Up to 85% of its capacity.In order to achieve the maximum capacity, the canal authorities made great efforts and renovation.But the main bottleneck is the pedro miguel lock on lake gaton.Therefore, the expansion of the canal is the top priority to further increase revenue and meet market demand.If get the expansion of the panama canal, built after the lock and the sum of the existing locks tonnage capacity will reach 600 million tons, is the capacity of existing 2 times, after a long period of time, can meet the market demand, per the panama canal almost won't appear the ship queue phenomena, all including large-scale ship can prevail.

In the past 100 years, with the prosperous development of water transport, ship construction has been gradually developing to large scale, and the previous small-scale ships have been increasingly unable to meet the needs.Moreover, the width and depth of the panama canal channel can not meet the demand of water transportation, resulting in frequent ship congestion, which greatly damages the competitiveness of the canal.In the past, ships that used the panama canal as a transit route chose to bypass the Suez Canal in order to avoid ship congestion. In recent years, the decline in oil prices has made the status of the panama canal even more precarious.

1.3. The Importance of Widening the Panama Canal

Officials say the move to widen the panama canal is the most important infrastructure project in more than 100 years and deserves national attention.This is not only the development of the

panama canal, but also a new era for the Panamanian people, and a new era for the relationship between the canal authority and its customers.The new panama canal will no longer be the "giant baby" with the "panama limit", but an "adult" with independent ability. The container capacity of the ships passing through panama will increase from 4,000 to 5,000 TEU (standard container) to 13,000 to 10,000 TEU.In recent years, 17,000 ships pass through the canal each year, and the annual cargo load has risen to 600 million tons from 300 million tons today.

2. Ways to Expand the Panama Canal

The expansion, suggested by panama canal officials, would use a third set of locks to improve the canal's capacity.There are four major projects completed:

2.1. Build A Third Set of Locks

The operation of the new lock will use tugs to locate ships in the lock, replacing the existing small train positioning system.

2.2. Excavation of the Waterway Leading to the New Lock

The canal authority has studied the feasibility of building a new bridge or tunnel across the canal while building new locks on the Atlantic side.

2.3. Deepening the Existing Channel and Raising the Highest Running Water Level of Gatong Lake

2.4. The Establishment of New Panamax Ships to Meet the Needs

In order to adapt to the expanded new panama canal and meet the needs of wider water transportation, three sets of locks were continuously used, which allowed more ship transportation and expanded the annual cargo capacity of the panama canal at a deeper level.

3. Looking at the New Trend of Shipping after the Widening of Panama Canal from the Perspective of Big Data

Comparison of each year from 2015 to 2017 years of ship by quantity, shipping by cargo volume in half a year and year tolls average income and all kinds of ships through the panama canal, obviously increasing each year, the data of the panama canal expansion advantage obviously, the data in 2017 by nearly 2018, there is no comparison, only compare expansion in June, 2016 a year and a half before and after completion of the data.

Table 1. Statistical table of panama canal data

year	2015	2016	2017
Annual vessel throughput (unit: ships)	10865	13114	13548
Annual vessel throughput (unit: ships)	4470+4615	4085+4775	5245+5430
Annual toll revenue (unit:billion balboa)	1.933	2.238	2.485
The average time for ships to pass through the panama canal(unit: hours)	13.83	12.58	12.45

By comparing the period from 2015 to 2017, the overall situation of 2018 is similar to that of 2017. No comparison will be made here.After the new expansion of the panama canal in July 2016, the gap in the water transport situation of the panama canal is obvious, which is obviously improved collectively.In 2016, more than 2,400 ships were shipped than in 2015, realizing the maximum utilization after the expansion of the canal. In 2017, more than 400 ships were

shipped than in 2016.In terms of shipping through goods, it is obvious that there is a big gap between the first half of 2016 and the second half of 2016. With the increase in the number of ships passing through, goods show a non-linear correlation.In the past three years, the annual passing fee has been rising continuously. I believe that in the future development, the income will definitely increase.Finally, the most important ship through the panama canal, average 2016 years ago, as there is no expansion of the panama canal, space is relatively narrow, often there will be a vessel congestion, waste of resources phenomenon, due to expanding, can save nearly 1 hour 30 minutes than before, whether to ship, or is new progress of the panama canal itself.

According to the data, we can draw these conclusions: the recovery rate of ships increases, the upsizing trend of ships is obvious, and the influence of canal widening on different ship types is different.

In order to predict the average time of ships passing through the panama canal in the following years of 2019, polynomial regression was used to find out the number of ships passing through each month (X) and the number of ships passing through cargo (Y)

Model prediction.

The image below is the image rendered by using Python software.From the graph, draw a polynomial regression function.

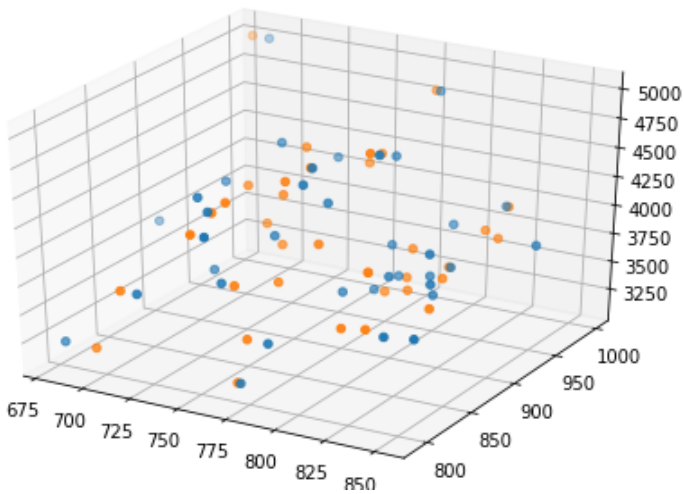

Figure 2. Image of polynomial regression model

Based on the basic data from January 2015 to June 2017, it has been fitted with Python for several times, and the cubic polynomial is as follows:

$$Z = 9.18431074\times10^{-4}X^3 - 2.44072837\times10X^2Y - 1.22035966\times10^2XY^2 + 1.07868964\times10^{-3}Y^3$$
$$+5.39344407\times10^{-3}X^2 + 2.69672148\times10^{-2}XY + 3.08904849\times10^{-7}Y^2 - 6.11524360\times10^{-6}X$$
$$+2.31247146\times10^{-6}Y - 2.28771786\times10^{-6}$$

The test error is 0.04 and the training error is 1.76.

As can be seen from the above table, the maximum error between the predicted value and the actual value of the average time of ships is within 3 minutes, the ship passing quantity is the best statistical, and the ship passing quantity is approximately 5000 times of the ship passing quantity, so it can directly predict the average time of ships passing, and predict whether further expansion is needed in the future.It can also carry out feasibility analysis of the expansion.After the widening of the panama canal, its navigation capacity has been greatly improved, which is conducive to the development of both sides of the Pacific and Atlantic oceans.

Table 2. Comparison of model predicted data and actual data

Month of 2017	July	August	September	October	November	December
Ship throughput	900	920	850	860	930	1000
The amount of cargo carried by a ship	4500	4600	4250	4300	4500	5000
Average passing time (predicted value)	757.5	786.5	728.1	722.9	730.0	689.9
Average passage time (actual value)	760	785	730	720	730	690
Difference between predicted value and actual value (min)	-2.5	1.5	-1.9	2.9	0	-0.1

4. Benefits to World Shipping Brought by the Expansion of the Panama Canal

China should continue to take an active part in the development of the world's strategic maritime corridor and expand its influence on the basis of cooperation.China needs to take cooperation and mutual benefit as the participation principles in major infrastructure projects, so as to hedge the risks and impacts brought by geopolitical games.

After the expansion of the panama canal, one of the most beneficial change is to make the traffic capacity is greatly increased, to a greater extent through more ships, which not only reduced the ship traffic unavailable, saves the manpower, but also through more ships, more goods, increase utilization rate of water transport, thus, the importance of water transport and efficiency.

For world shipping, on the one hand, it is conducive to meeting the needs of crossing the river in the shipping market; on the other hand, it is also conducive to the development of large-scale eel ships; and on the third hand, it is conducive to meeting more route choices of liner operators.Finally, the expansion of the panama canal also brings considerable income to panama, making panama become the shipping center of Latin America and making greater contribution to the further development of the world shipping industry.

5. References

[1] Zhang hongwen. Introduction to the new panama canal [J]. Navigation technology,2017(02):23-25.

[2] MARIC 13800 teu container ship [J]. Ship, 2008,29(06):97-99.

[3] Wang jian. One Belt And One Road even china-pakistan win-win cooperation for development [N]. International business journal,2018-12-04(009).

[4] Wang peng. The expanded panama canal and its enlightenment to China [J]. Contemporary world,2016(11):62-65.

[5] William o 'neill. A global perspective on the expansion of the panama canal and the development of shipping industry [J]. Containerization,2007(07):1-4.

[6] Wang jiawei. A geographical perspective on the expanded new panama canal [J]. Geography teaching,2017(02):6-8.

[7] li jian, mou yan. Canal tolls game under panama canal expansion [J]. Ocean development and management, 2008,35(04):113-116.

[8] Xie wei. How much economic benefit can the expansion of the panama canal bring?[J]. China economic weekly,2016(27):72-73.

[9] Cai meijiang. Expansion of panama canal and its impact on world shipping [J]. China ocean shipping,2008(02):69-71.

[10] Lin dehui, shen hongmin. Panama canal shipping notice and requirements for ships [J]. Ship standardization and quality,2008(05):41-44+40.