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REPORT

Review of OSC's Container Traffic Forecast Study – Port of Vancouver, 2016

PREPARED FOR
Vancouver Fraser Port Authority

PREPARED BY
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Executive Summary

InterVISTAS Consulting Inc. was asked to review the 2016 forecast of container traffic volumes for the Port of Vancouver, and offer an expert opinion as to whether the forecast methodology meets an acceptable and good standard and whether the resulting forecast is reasonable. The forecast was prepared by Ocean Shipping Consultants and covers two periods: a) the short to medium term period to 2025, and the long term to 2050.

Who did this review? Dr. Michael Tretheway, Chief Economist of the InterVISTAS Consulting Group conducted this review. Dr. Tretheway, a former Transportation & Logistics faculty member of the Sauder School of Business at the University of British Columbia, is an economist and has been forecasting traffic in the transportation and utilities sectors for over 35 years. He has been an advisor on forecasting methodologies to Transport Canada, was a visiting fellow at the Australian Bureau of Transport Economics and has been a member of a number of transportation sector working groups for the Organization for Economic Cooperation and Development (OECD). He is familiar with and has conducted forecasting in the aviation, maritime, rail, urban transport, electric power and natural gas sectors.

Forecasting Methodology. There are a number of potential forecasting methodologies that could be used to forecast Port of Vancouver container traffic.

- Perhaps the most common but also the most likely to produce naïve long term forecasts is to merely use historical information of Port of Vancouver traffic volumes and link these through an econometric or similar model to macroeconomic and social variables such as growth in Gross Domestic Product, energy prices, international trade and population. This method, while it would be very specific to Port of Vancouver traffic volumes can make serious long term errors by failing to understand and incorporate broader global developments. An example is the impact on West Coast North American ports from the expanded Panama Canal and the developments of the Suez Canal. A large component of Port of Vancouver traffic is trade from Asia destined to north central North American markets such as Toronto and Chicago, and these destinations can receive goods via the Panama or Suez canals to East Coast and Gulf of Mexico ports.

- An alternative is what might be called a top down forecast, which reaches a final forecast for Port of Vancouver through a series of steps beginning with a forecast of total North American container traffic, then in stages breaks the forecasted “macro” container volumes down by steps such as East/Gulf Coast vs. West Coast, Southern ports on West Coast versus Northwest Ports, US Norwest coast ports vs. Canadian gateway ports, and finally the split between Prince Rupert and Port of Vancouver. A top down forecast, if properly designed and executed, is more likely to identify and analyse the impacts of broad trends affecting container traffic, as well as port competitiveness factors, and thus produce a more thoughtful and more accurate forecast of Port of Vancouver container volumes. This is the approach used by OSC.

What constitutes good forecasting? There are a number of factors that determine whether a long term forecast can be judged to be reasonable. These are not merely how sophisticated is the statistical analysis and modelling methodology. More important than anything is whether the forecaster understands the long term major factors driving traffic volumes, not merely locally but on a much broader scale. These factors include demand and supply factors, geopolitical factors, pricing and competitiveness, changes in how user industries (e.g., the automotive sector) arrange their logistics and choose supply channels, whether historical traffic volumes were constrained by capacity limits at competitor ports and how those capacity limits may be eased in the future. A good forecast methodlogy will recognize that the future is uncertain, and that the medium to long term traffic levels cannot be forecast as a single traffic level in a

particular year, but rather as a range of potential traffic volumes for future years. To consider the key local and global factors, good forecasting requires substantial amounts of data, both in terms of the range of number and types of factors to be measured and a long time series in terms of years of data. Variables must include not only traffic and the usual socio economic measures like GDP and population, but also port competitiveness factors on fees, capacity, physical measures (such as berth depth and length), etc. The data must be accurate and the measures meaningful.

Good forecasting also recognises that economies mature, technology changes, productivity improves, and competitive conditions evolve, sometimes disruptively.

Good forecasting for ports cannot be done in isolation but rather in terms of the supply chains that the port participates in and the supply chains that the port competes with. Forecasting high traffic growth becomes meaningless if, for example, rail capacity cannot accommodate growth, or port operational facilities are limited and congestion occurs. Good forecasting will start with unconstrained demand potential but then consider supply side constraints, both of the port itself as well as other supply chain links and nodes.

Finally, good forecasting requires good documentation and must be transparent regarding assumptions, data, computations and methodology. Only then can the veracity of the forecast be fully evaluated and tested.

The OSC forecast of Port of Vancouver container traffic. The OSC forecast can be characterized as follows:

1. It uses a top down approach, first forecasting trade volumes in key markets such as Asia to North America. It then forecasts how trade will materialise into continental container volumes. This stage recognizes that there is a productivity trend with containers carrying slightly higher weights resulting in fewer containers required for a given volume by weight in a number of commodity categories. OSC examines flows by trade lane, and by major commodity type.

2. The forecasted North American container volumes are then parsed into volumes for the East/Gulf and West coasts, then further between Southwest and Northwest ports, then into US northwest ports vs the Canadian gateways and finally into volumes for Port of Vancouver. At each step OSC discusses the key historical drivers and likely future development that will impact the competitiveness of each of the ports. As an example the coastal split is considered in the context of Panama and Suez Canal developments and rail capacity issues. The distribution of traffic by seaboard takes into consideration of the underlying distribution costs (both marine/port and intermodal services) as well as expected competitive developments. The relative competitive position of the ports helps define the role of PNW ports in the continental market.

3. OSC identifies the specific hinterlands that particular ports serve and then assesses economic and other developments expected in those regions. The Pacific Northwest ports tend to serve the major markets in the upper Midwest of the U.S. (and central Canada), while the Southwest ports are more focused on the industrial and consumer areas in the U.S. southern Midwest. It is the latter markets that are more affected by the Panama Canal expansion.

4. At each stage, OSC discusses the trends at each port and in each hinterland. The discussion is not merely qualitative, but rather uses a number of long time services charts and tables to quantify past and future trends.

5. This results in an OSC forecast for what is called ‘unconstrained’ or ‘potential’ demand. That is, how many containers are forecasted for the Port of Vancouver if there are no constraints in terms of port capacity, supply chain capacity, etc.?

6. OSC forecasts separately for two time periods. The first is 2017 to 2025, which might be called the short to medium term. This forecast uses a trend methodology. This forecast uses external forecasts of GDP at overseas origin points and at North American destinations (and vice versa). Coefficients are developed for how GDP drives container volume and these coefficients are posited to attenuate over time, reflecting market maturation, competitive developments and container trade productivity improvements. Forecasts are developed for three scenarios: base case, low scenario and high scenario. The scenarios are based on specific (and clearly stated/documented) assumptions regarding economic growth and energy prices, financial market and currency stability, developments in trade agreements and frameworks, and trade/investment climate. Inbound (import) and outbound (export) container flows are modeled separately, but using a similar approach. Four specific risk/opportunity factors are considered: US PNW port capacity issues, increases in Port of Vancouver intermodal transportation, changes in relative costs/charges of competing ports, and changes in Port of Vancouver market shares, mainly based on changes in ship size and draught requirements.

7. For the long term from 2025 to 2050 a greater range of scenario developments are considered by OSC. Factors given greater weight for the long term forecast include:

    - Limits on economic growth.
    - Political stability.
    - Changes in production and consumption locations.
    - Long term technical changes that affect maritime operations as well as changes in products consumed.
    - Major changes in port competitive positions, including port fees.
    - Whether the world, or particular nations, move away from free trade to protectionist policies.

8. For the post 2025 periods, OSC posits three main scenarios: continuing free trade (basically a continuation of the High case of the 2017-2025 forecast); a move to partial protectionism (Base case); and a new economic and trade paradigm driven by environmental and sustainability concerns (Low case). Even within the continuing free trade scenario OSC further assumes that growth rates will attenuate over time. It posits lower GDP and trade growth in the period 2036-2050 than it does for the period 2026-2035. This is a reasonable approach as the relevant markets further mature. This approach is also used in the other two scenarios.

9. After forecasting potential container demand, OSC then considers a range of supply factors that can constrain Port of Vancouver traffic volumes. Port capacity is a major factor, both at Port of Vancouver as well as at its competitor ports. OSC reviews port investment opportunities and plans location by location and assesses the impact on Port of Vancouver container volumes. It also looks at port costs and how Port of Vancouver ranks competitively. The cost competitiveness analysis is holistic in that it considers not only port fees but total supply chain costs including voyage costs, port costs and rail/truck costs to final delivery point. OSC examines the complete range of fees, in order to get an apples-to-apples comparison, noting that sometimes a basic

charge for the movement of a container from vessel to the yard during normal working hours will not include charges for other activities (e.g., hatch opening, lashing, etc.) which are billed later.

10. Of particular importance is to examine scenarios for both import and export container demand. If container traffic is largely eastbound, other ports will be better able to compete and reduce Port of Vancouver market share, whereas if westbound volumes also build there are several effects that create more stability for Port of Vancouver traffic. These include the ability for maritime lines to offer lower rates since the costs of container return and home voyage are now offset by backhaul volumes rather than empty containers. This is true not only for the container use but also for voyage costs and rail transport. The long term forecasts also considers key developments in vessel size and whether there are limits to the observed long term increase in vessel size (and hence reduced container costs).

    OSC also considers the degree to which containerized imports can continue to grow before reaching a saturation point. Per capita consumption of a number of commodities (e.g., food products) is limited, and there are also political implications of becoming too reliant on imports in certain strategic areas. There are thus limits to growth of inbound containers which manifest in the longer term portion of the OSC forecast.

    Scenarios considered for the post 2025 world include a continuation of the forces leading to more open trade, a reversion to a partially protectionist world, and the development of a new economic and trade paradigm based on environmental/sustainability concerns. These three scenarios are reflected in the continuation of the high case, base case and low case forecasts post 2025.

11. OSC's assessment of the competitiveness of Port of Vancouver relative to its competitor ports is not limited to cost competitiveness. OSC also considers factors such as the physical and planned capacity of the ports, their productivity, local demand, location as a regional hub and the existing customer base. This provides a more complete basis for the forecast, since while cost is likely the key issue for most shippers, these other elements will affect the traffic volumes actually achieved. OSC's assessment is that not only does Vancouver provide a cost-effective alternative to its competitors, they find the Port of Vancouver is competitive with its peers on several other elements. OSC notes, however, that this overall competitiveness must be maintained moving forward if the forecasted volumes are to materialize.

The OSC forecast meets the standard. It is my opinion that the OSC forecast meets the standard of a good forecasting methodology and provides a reasonable result. Its use of a top down approach ensures that it must consider continent wide trends and developments. It is not narrowly focusing on trends at Port of Vancouver. Its data development is extensive, covers major relevant elements including what is happening at other ports, competitiveness in fees and charges, and beyond that to supply chain competitiveness. Its forecast anticipates long term developments in terms of economic market maturity, technical change, changes in location of supply and demand, and potential for major shifts in geopolitical stability and attitudes toward trade.

Developments in the Treatment of Risk in forecasting. The OSC forecast considers a number of major risk factors, including things such as long term economic stagnation and the potential for some nations to move toward trade protectionist policies. However it incorporates these risk elements via specific assumptions for a small number of potential future long run scenarios. For the long run forecasts to 2050 it posits a small number of scenarios. This produces a range of potential future traffic outcomes (the lowest of which still posits significant growth in Port of Vancouver container traffic from roughly 3 million to 6 million TEUs). In recent years the treatment of risk in forecasting has evolved to a) consider a wider range of risk factors including "black swan" (low probability but high impact events), b) to specify these factors with probability distributions, and c) to undertake a large number (typically 10,000) of

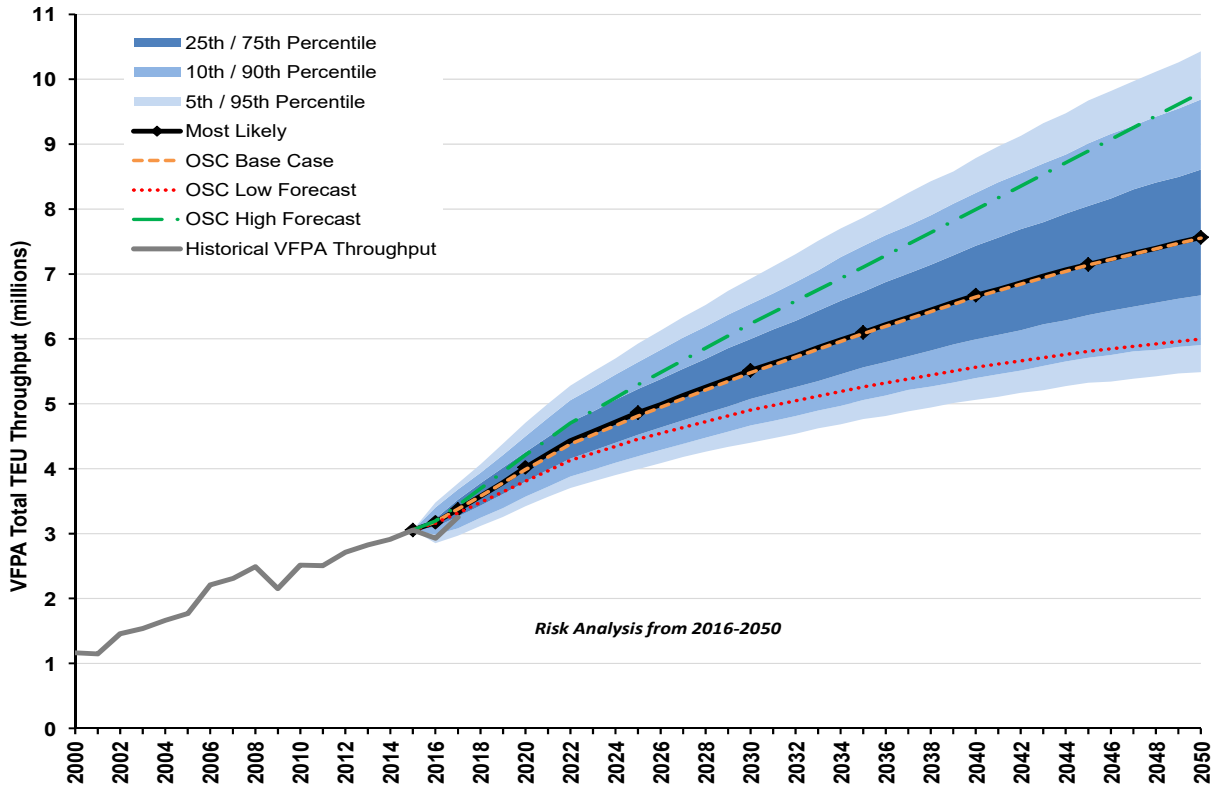
potential scenarios. InterVISTAS refers to this probability based methodologies as 'stochastic' forecasting.

There are several advantages to this approach. First, it allows probabilities to be assigned to outcomes. The traditional risk approach used by OSC (and also the method used by Transport Canada) posits high and low scenarios but with no probability of these being the outcomes – nor is there a probability of the base case as an outcome. Second, stochastic forecasting provides probability ranges, such as the central 50% probability band for traffic levels, or the 20%-80% band, etc. Third, it also allows addressing questions such as what is the probability that there will be no traffic growth or that traffic growth falls below the level needed to justify an expansion project.

Risk augmented forecast of Port of Vancouver Container Traffic. InterVISTAS recommended to augment the OSC base/high/low case approach with a risk-based forecasting approach based around the OSC base case in order to be able to ascertain probabilities of alternative volumes. The Port of Vancouver agreed to this and as described below, we implemented the risk based analysis. The risk augmented methodology is built around the core forecasting methodology used by OSC for its base case as a complement to its existing analysis. This approach allows for a greater range of risk factors that could influence the expected results, and simulates 10,000 possible scenarios. Augmenting the OSC forecast, we see that the OSC high case and low case fall within the 10th to 90th percentile of likely outcomes. The following figure graphically depicts the risk augmented forecast. I observe:

InterVISTAS' Risk Analysis of OSC Forecast for VFPA TEUs

25 May 2018



- The OSC base case corresponds closely with the most likely risk forecast.
- The OSC high and low forecasts correspond roughly with the 10% and 90% risk profiles. We estimate that there is only 10% risk that Port of Vancouver traffic will be less than the low forecast of OSC.
- In the short run there is some risk of traffic decline (as well as traffic increase).
- The risk bands get wider over time as the more distant future has more uncertainty than the short term.
- In the medium to long term, there is a high likelihood that Port of Vancouver container traffic will increase considerably, even after considering the possibility that competing ports will undertake developments of their own.

Contents

1 Introduction

1.1 Engagement

InterVISTAS was retained in November 2017 by the Vancouver Fraser Port Authority to provide a professional review of the 2016 container traffic forecast prepared for the Pot of Vancouver by Ocean Shipping Consultants (OSC).

Neither I nor my firm InterVISTAS were involved in the preparation of that 2016 forecast, nor of the earlier forecasts prepared by OSC for the Port of Vancouver.

In collecting some background documents I have used in my statement I have utilised research staff of my consulting firm, Inter*VISTAS* Consulting Inc. For all such assistance, the individuals involved report to or through me, and for these tasks they were directly supervised by me. I have reviewed all information provided and all research undertaken. The opinions expressed in this report are mine and mine alone.

1.1.1 Relationship between InterVISTAS Consulting Inc. and Ocean Shipping Consultants

InterVISTAS Consulting Inc. (IVC) is a transportation/aviation/tourism consulting practice founded in Vancouver Canada. In 2008 IVC was purchased by a predecessor of Royal Haskoning DHV (RHDHV). RHDHV, which itself has a major maritime engineering and project management consultancy, purchased OSC in 2014. However, OSC and IVC are each independent firms and not jointly managed in terms of our practice. Any joint management is with respecting to accounting and finance, human resources policies and other administrative matters. We do not market together and have not participated in joint projects. We are independent firms.

1.1.2 Questions to be Addressed

The forecast was reviewed in terms of:

- whether the forecast methodology meets an acceptable and good standard, and
- whether the resulting forecast is reasonable.

1.1.3 My Statement of Identity and Interest

This report was prepared by Dr. Michael W. Tretheway. I reside at 12471 Alliance Drive, Richmond, British Columbia, Canada.

I am currently Executive Vice President, Chief Economist and Chief Strategy Officer of the Inter*VISTAS* Consulting Group. Inter*VISTAS* Consulting Inc., a Canadian company, is 100% owned by Royal Haskoning DHV based in Amersfoort in the Netherlands. Inter*VISTAS* forms part of the Aviation Business Line within Royal Haskoning DHV, a global provider of consultancy and engineering services in the areas of aviation, transportation, water, environment, building and manufacturing, mining and hydropower.

From 1983-1996, I was a full time faculty member (Associate Professor) in the Sauder School of Business of the University of British Columbia. Since 1997 I have been an Adjunct Professor for most years, except for short periods between appointment renewals. My most recent appoint has lapsed and has not yet been renewed.

I do not have any financial interest in the outcome of this proceeding. My compensation for my services is based on hours worked and my expenses, and has no incentive or penalty based on the outcome of this proceeding.

1.1.4 Area of Expertise and Qualifications

Appendix A contains a statement of my qualifications. Appendix B provides my Curriculum Vitae.

In brief, I have a PhD in Economics from the University of Wisconsin (1981). My major field was econometrics, which is the field that uses statistical techniques to obtain empirical information on economic markets, including forecasting. My 2nd field was monetary economics. From 1983-1996 I taught in the Transportation and Logistics Division of the Sauder School of Business at the University of British Columbia (UBC), where I taught business logistics, Air Transport Management and Economics, managerial economics, cost benefit analysis and business statistics, among other courses. Since leaving full time employment at UBC I have held an appointment as an unpaid Adjunct Professor for most years, with gaps due to the time required to review appointments. I have actively published in the field of transport economics in peer reviewed journals. I was Executive Advisor to the President of the Vancouver International Airport Authority (Honourable Dr. David Emerson) and later Vice President of Marketing Services for the Airport Authority. I co-founded InterVISTAS Consulting in 1997, a major aviation, transportation and tourism consulting practice, headquartered in Vancouver. Until May 2018 I was the Managing Director, Canada, and currently I have the titles of Executive Vice President and Chief Economist for the InterVISTAS Consulting Group.

I have testified in roughly 80 court or tribunal proceedings, regulatory hearings and arbitrations, and have done so in Canada, the U.S., New Zealand, Australia, Hong Kong, South Africa, and before the European Commission. In all these proceedings my qualifications have been accepted.

My area of expertise in this matter is in transportation economics, including forecasting of port terminal traffic.

1.1.5 Summary of My Opinion

(i) Does the OSC container forecast methodology meet a good standard for port traffic forecasting and does it provide a reasonable forecast?

In addressing this question, I compared the OSC forecast to what constitutes good forecasting. My key observations are:

- OSC adopted an appropriate methodology for the situation.
- OSC executed the methodology competently.
- OSC developed an extensive database using reliable sources and verifying the consistency of the data to the extent possible in order to support the forecast. OSC also made clear the assumptions used that are drivers for the forecast.
- OSC, in undertaking the forecast, showed a deep understanding of the macro factors that could affect the traffic the Port of Vancouver handles. Their forecast goes beyond drivers such as GDP and relationship of trade to GDP: it conducts the forecast in the context of the Panama and Suez Canal developments, catchment areas, trends in ship size and draught requirements, rail capacity issues, total supply chain costs of competing options, and other factors.
- The development of three scenarios, with four specific risk/opportunity factors gives Port of Vancouver an understanding of a range of traffic outcomes over the forecast period.

My opinion is that the OSC forecast meets the standard of a good forecasting methodology and provides a reasonable traffic forecast. Its use of a top down approach ensures that it must consider continent wide trends and developments. It is not narrowly focusing on trends at Port of Vancouver. Its data development is extensive, covers major relevant elements including what is happening at other ports, competitiveness in fees and charges and beyond that to supply chain competitiveness. Its forecast anticipates long term developments in terms of economic market maturity, technical change, changes in location of supply and demand, and potential for major shifts in geopolitical stability and attitudes toward trade.

(ii) What can be learned from a risk based enhancement to the OSC forecast?

In addressing this question, I utilized a risk based traffic forecasting approach that I developed as a principle investigator for the U.S. National Academy of Sciences Transportation Research Board. That study was doubly peer reviewed, with reviews by academics and by airport practitioners. The forecast methodology was developed in the context of airport traffic forecasting, but the methodology is fully applicable to ports as was the common port/airport forecasting methodology used by Transport Canada until it delegated its ports and airports to independent, locally based authorities.

I augmented the OSC base/high/low case approach with a risk-based forecasting approach based around the OSC base case in order to be able to ascertain probabilities of alternative volumes. The risk augmented methodology is built around the core forecasting methodology used by OSC for its base case as a complement to its existing analysis. This approach allows for a greater range of risk factors that could influence the expected results, and simulates 10,000 possible scenarios. Augmenting the OSC forecast, I found that the OSC high case and low case fall within the 10^{th} to 90^{th} percentile of likely outcomes.

My key observations are:

- In a good forecast model, such as the OSC forecast, the traditional base case corresponds very closely to the 50% probability line (which is called the most likely forecast) in the stochastic terminology. It seems unlikely that incorporating stochastic risk analysis will substantially change the base case forecast. That is the case for my analysis. The OSC base case corresponds closely with the most likely risk forecast.

- Like the OSC forecasts, the stochastic forecast range is not symmetric. The OSC high forecasts are a somewhat greater magnitude above the base case than the low scenario is below the base case. Essentially the OSC forecast has a somewhat higher upside above the base than the low side is below. We expected the risk based forecast to also be asymmetrical and that is the case. There is no guarantee that the high side deviation will be larger than the low side deviation from the base case. Incorporating "black swan" events (e.g., the impact of an earthquake on port traffic) result in substantial low side outcomes. But when a facility is highly competitive and its competitors also face formidable challenges then high side outcomes may dominate the low side.

- Augmenting the OSC forecast, we see that the OSC high case and low case fall within the 10^{th} to 90^{th} percentile of likely outcomes.

- The OSC high and low forecasts correspond roughly with the 10% and 90% risk profiles. We estimate that there is only 10% risk that Port of Vancouver traffic will be less than the low forecast of OSC.

- In the short run there is some risk of traffic decline (as well as traffic increase). This was not revealed in the OSC forecasts. Its short run low case still had a modest traffic increase, whereas the wider number of scenarios considered in the InterVISTAS risk based forecast brings out the small probabilities of a short run traffic decline.

- The risk bands get wider over time as the more distant future has more uncertainty than the short term.

- In the medium to long term, there is a high likelihood that Port of Vancouver container traffic will increase considerably, even after considering the possibility that competing ports will undertake developments of their own.

2 Forecasting: What Constitutes a Good Forecast

2.1 Potential methodologies

Although different practitioners will offer different definitions of "types of forecasting methodologies," I categorize forecast methodologies into four basic categories: qualitative techniques, time series analysis and projection, causality modelling, and simulation.

Qualitative techniques include approaches such as expert opinion, Delphi technique[1], polling/surveys, etc. This approach is most commonly used when forecasting traffic volumes (or sales or outputs of various types) when no historical data exists. For example, forecasting sales of a new product, or traffic volumes for a new mode of transport, or traffic volumes from a new type of traffic served by an existing port, will often resort to qualitative techniques since there is no historical data to evaluate trends, or determine causality. In the case of container forecasts at the Port of Vancouver, considerable historical data exists, and the preference is to utilize this data in producing the forecast using one or more of the other methodologies.

Time series analysis and projection attempt to discern patterns of past container volumes to project how those patterns will evolve in the future. It essentially extrapolates past volumes to produce forecasts of future volumes. The forecaster generally tries to break down the historical data into constituent components such as baseline trend, seasonal patterns, cyclical patterns and random fluctuations. Common approaches include moving averages, exponential smoothing, or simple regressions to fit the best trend line to the historical data. This is a very common approach to forecasting traffic volumes, and is the approach historically used by Transport Canada for port traffic, airport traffic and aircraft movements.

Causality modelling examines drivers of traffic volumes (e.g., GDP, population, international trade, rates/fares, etc.) and develops a model which "explains" how traffic changes in response to changes in these drivers. It uses forecasts of changes in these variables to project how traffic will change in response. Like time series analysis and projection, causality modelling is based on historical data, but it has the flexibility to incorporate specific independent variables that can have a material impact on past trends. Common approaches include relatively simple linear or non-linear regression models, more complex econometric models that involve a number of interdependent regression equations and input/output models.[2]

Even in the case of causality modes, there is a risk that it can produce naïve forecasts. If one merely uses historical information of Port of Vancouver traffic volumes and links these through an econometric or similar model to macroeconomic and social variables such as growth in Gross Domestic Product, energy prices, international trade and population, there is a potential issue. This method, while it would be very specific to Port of Vancouver traffic volumes, can make serious long term errors by failing to understand and incorporate broader global developments. An example is the impact on West Coast North American ports from the expanded Panama Canal and the developments of the Suez Canal. A large component of Port of Vancouver traffic is trade from Asia destined to north central North American markets such as

[1] The Delphi approach relies on an iterative approach by a panel of experts which is designed, after producing and discussing forecast results and rationales in a number of rounds, to converge on the most likely forecast.

[2] Development of an input/output model is a very expensive proposition, and is not often used for forecasting exercises.

Toronto and Chicago, and these destinations can also receive goods via the Panama or Suez canals to East Coast and Gulf of Mexico ports.

An alternative is what might be called a top down forecast, which reaches a final forecast for Port of Vancouver through a series of steps beginning with a forecast of total North American container traffic, then in stages breaks the forecasted “macro” container volumes down by steps such as East/Gulf Coast vs. West Coast, Southern ports on West Coast versus Northwest Ports, US Northwest coast ports vs. Canadian gateway ports, and finally the split between Prince Rupert and Port of Vancouver. A top down forecast, if properly designed and executed is more likely to identify and analyse the impacts of broad trends affecting container traffic, as well as port competitiveness factors, and thus produce a more thoughtful and more accurate forecast of Port of Vancouver container volumes. This is the approach used by OSC.

Finally, the fourth general approach is simulation modelling. This is a more sophisticated approach than the others as it attempts to replicate potential outcomes of various possibilities of the key factors in a complex system. In other words, it incorporates the element of risk associated with each of the drivers of traffic. The use of Monte Carlo simulation, for example, produces thousands of possible future outcomes based on the probabilities that certain events will occur. For example, a terrorist attack on the Port of Vancouver, or the Port of Seattle/Tacoma, will affect container traffic volumes in Vancouver. We do not know if or when such an attack might occur, but can assign a probability that one might happen at some point during the forecast period. By running the model many times, we can obtain a distribution which indicates how likely each forecast volume is. Thus rather than a simple, base case, low case and high case as is usually developed with time series and causal models, a simulation model can forecast the probability that a volume greater than X, or a volume less than Y, will happen in a given year. This is the approach I took to produce the results reported in chapter 6.

I should note that the choice of which approach to use will depend on a number of factors:

a) The purpose of the forecast. If the forecast is for a land-use plan that will determine what existing lands at a port or airport should be set aside for what purpose, a high-level more general approach is likely adequate. If the forecast is to determine whether or not a specific large infrastructure investment should be made, a more detailed sophisticated approach is likely warranted.

b) The specifics of the subject being forecast. The less the historical variation, the more likely that simple approaches would suffice to give reasonable forecasts. The greater the impact that misjudging the forecast has on the entity, the more likely the greater amount of time and money required for the more sophisticated approaches will be warranted.

c) Whether we are dealing with something that will likely not be subject to a disruptive event or that might be significantly impacted by a foreseeable event (new competitor, new product, new business models, etc.) will have an influence on choice of approach. In the case of a disruptive event, a qualitative approach might be selected on the grounds that the historical data will have less relevance in the new environment.

2.2 What constitutes good forecasting?

There are a number of factors that determine whether a forecast can be judged to be reasonable.

At the most basic level, whether a long term forecast is reasonable depends on whether the right approach was taken. Was a qualitative approach taken when adequate historical data exists for a quantitative approach and no major disruptive event is reasonably anticipated that could invalidate a quantitative analysis based on historical data? Was a quantitative approach adopted when a major disruptive force is anticipated that would upset the historical relationships between volumes and key drivers? Was a time series analysis and projection used when the historical trends can be expected to

change because of key changes to drivers such as capacity expansion of a nearby competing port? The selection of the appropriate approach is key to a good forecast.

Next is how well the chosen approach was executed. Was the use of polling/surveys in a qualitative forecast based on poorly thought out or worded questions? Did a regression analysis used in a quantitative approach use Ordinary Least Squares when endogeneity exists (i.e., when the dependent variable's error terms are correlated with the 'independent' variable(s)) and two-stage least squares should have been used? The proper execution of an appropriate forecasting approach is also key to good forecasting.

Closely associated with execution of the chosen approach is the quality of the data used in the approach. Was a consistent source of data used for each of the variables of interest? If not, did the various sources offer an apples-to-apples measurement? For example, was container throughput measured on a comparable basis, or were certain elements (e.g., transhipment, transloading from marine containers to 53' domestic containers) assessed inconsistently? Were these data from reliable sources? Are they well documented?

What constitutes good forecasting, however, goes beyond the choice of model and how well it was executed. Good forecasting goes beyond merely how sophisticated is the statistical analysis and modelling. More important than anything is whether the forecaster understands the major factors driving traffic volumes, not merely locally but on a much broader scale. These include demand and supply factors, geopolitical factors, pricing and competitiveness, changes in how user industries (e.g., the automotive sector) arrange their logistics and choose supply channels, whether historical traffic volumes were constrained by capacity limits at competitor ports and how those capacity limits may be eased in the future. A good forecast will recognize that the future is uncertain, and that the medium to long term traffic levels cannot be forecast as a single traffic level in a particular year, but rather as a range of potential traffic volumes.

To consider this wide range of local and global factors, good forecasting requires substantial amounts of data, both in terms of the range of factors to be measured and a long range in terms of years of data. Variables must include not only traffic and the usual socio economic measures like GDP and population, but also port competitiveness factors on fees, capacity, physical measures (such as berth depth and length), etc. The data must be accurate and the measures meaningful.

Good forecasting also recognises that economies mature, technologies change, productivity improves (or declines), and competitive conditions evolve, sometimes disruptively.

Good forecasting for ports cannot be done in isolation but rather in terms of the supply chains that the port participates in and the supply chains that the port competes with. Forecasting high traffic growth becomes meaningless if, for example, rail capacity cannot accommodate growth, or port operational facilities are limited and congestion occurs. Good forecasting will start with unconstrained demand potential but then consider supply side constraints, both of the port itself as well as other supply chain links and nodes.

Finally, good forecasting requires good documentation and must be transparent regarding assumptions, data, computations and methodology. Only then can the veracity of the forecast be fully evaluated and tested.

3 The OSC Forecast Approach for Port of Vancouver Container Traffic

3.1 The OSC forecast approach

The OSC forecast can be characterized as follows:

1. It uses a top down approach, first forecasting trade volumes in key markets such as Asia to North America. It then forecasts how trade will materialise into continental container volumes. This stage recognizes that there is a productivity trend with containers carrying slightly higher weights resulting in fewer containers required for a given volume by weight in a number of commodity categories. OSC examines flows by trade lane, and by major commodity type.

2. The forecasted North American container volumes are then parsed into volumes for the East/Gulf and West coasts, then further between Southwest and Northwest ports, then into US northwest ports vs the Canadian gateways and finally into volumes for Port of Vancouver and Prince Rupert. At each step OSC discusses the key historical drivers and likely future development that will impact the competitiveness of each of the ports. As an example the coastal split is considered in the context of Panama and Suez Canal developments and rail capacity issues. The distribution of traffic by seaboard takes into consideration of the underlying distribution costs (both marine/port and intermodal services) as well as expected competitive developments. The relative competitive position of the ports helps define the role of PNW ports in the continental market.

3. OSC identifies the specific hinterlands particular ports serve and then assesses economic and other developments expected in those regions. The Northwest ports tend to serve the major markets in the upper Midwest of the U.S. and central Canada, while the Southwest ports are more focused on the industrial and consumer areas in the U.S. southern Midwest. It is the latter markets that are more affected by the Panama Canal expansion.

4. At each stage, OSC discusses the trends at each port and in each hinterland. The discussion is not merely qualitative, but rather uses a number of long time services charts and tables to quantify past and future trends.

5. This results in an OSC forecast for what is called ‘unconstrained’ or ‘potential’ demand. That is, how many containers are forecasted for Port of Vancouver if there are no constraints in terms of port capacity, supply chain capacity, etc.

6. OSC forecasts separately for two time periods. The first is 2017 to 2025, which might be called the short to medium term. This forecast uses a trend methodology. This forecast uses external forecasts of GDP at overseas origin points and at North American destinations (and vice versa). Coefficients are developed for how GDP drives container volume and these coefficients are posited to attenuate over time, reflecting market maturation, competitive developments and container trade productivity improvements. Forecasts are developed for three scenarios: base case, low scenario and high scenario. The scenarios are based on specific (and clearly stated/documented) assumptions regarding economic growth and energy prices, financial market and currency stability, developments in trade agreements and frameworks, and trade/investment climate. Inbound (import) and outbound (export) container flows are modeled separately, but using a similar approach. Four specific risk/opportunity factors are considered: US PNW port capacity issues, increases in Port of Vancouver intermodal transportation, changes in relative costs/charges of competing ports, and changes in Port of Vancouver shares, mainly based on changes in ship size and draught requirements.

7. For the long term from 2025 to 2050 a greater range of scenario developments are considered by OSC. Factors given greater weight for the long term forecast include:

    - Limits on economic growth.
    - Political stability.
    - Changes in production and consumption locations.
    - Long term technical changes that affect maritime operations as well as changes in products consumed.
    - Major changes in port competitive positions, including port fees.
    - Whether the world, or particular nations move away from free trade to protectionist policies.

8. For the post 2025 periods, OSC posits three main scenarios: continuing free trade (basically a continuation of the High case of the 2017-2025 forecast); a move to partial protectionism (Base case); and a new economic and trade paradigm driven by environmental and sustainability concerns (Low case). Even within the continuing free trade scenario, OSC further assumes that growth rates will attenuate over time. It posits lower GDP and trade growth in the period 2036-2050 than it does for the period 2026-2035. This is a reasonable approach as the relevant markets further mature. This approach is also used in the other two scenarios.

9. After forecasting potential container demand, OSC then considers a range of supply factors that can constrain Port of Vancouver traffic volumes. Port capacity, both at Port of Vancouver as well as at its competitor ports is a major factor. OSC reviews port investment opportunities and plans location by location and assesses the impact on Port of Vancouver container volumes. It also looks at port costs and how Port of Vancouver ranks competitively. The cost competitiveness analysis is holistic in that it considers not only port fees but total supply chain costs including voyage costs, port costs and rail/truck costs to final delivery point. OSC examines the complete range of fees, in order to get an apples-to-apples comparison, noting that sometimes a basic charge for the movement of a container from vessel to the yard during normal working hours will not include charges for other activities (e.g., hatch opening, lashing, etc.) which are billed later.

10. Of particular importance is to examine scenarios for both import and export container demand. If container traffic is largely eastbound, other ports may be better able to compete and reduce Port of Vancouver market share, whereas if westbound volumes are also considered there are several effects that create more stability and competitiveness for Port of Vancouver traffic. These include the ability for maritime lines to offer lower rates since the costs of container return and home voyage are now offset by backhaul volumes rather than empty containers. This is true not only for the container use but also for voyage costs and rail transport. The long term forecasts also consider key developments in vessel size and whether there are limits to the observed long term increase in vessel size (and hence reduced container costs).

    OSC also considers the degree to which containerized imports can continue to grow before reaching a saturation point. Per capita consumption of a number of commodities (e.g., food products) is limited, and there are also political implications of becoming too reliant on imports in certain strategic areas. There are thus limits to growth of inbound containers which manifest in the longer term portion of the OSC forecast.

    Scenarios considered for the post 2025 world include a continuation of the forces leading to more open trade, a reversion to a partially protectionist world, and the development of a new economic

and trade paradigm based on environmental/sustainability concerns. These three scenarios are reflected in the continuation of the high case, base case and low case forecasts post 2025.

11. OSC's assessment of the competitiveness of Port of Vancouver relative to its competitor ports is not limited to cost competitiveness. OSC also considers factors such as the physical and planned capacity of the ports, their productivity, local demand, location as a regional hub and the existing customer base. This provides a more complete basis for the forecast, since while cost is likely the key issue for most shippers, these other elements will affect the traffic volumes actually achieved. OSC's assessment is that not only does Vancouver provide a cost-effective alternative to its competitors, they find the Port of Vancouver is competitive with its peers on several other elements. OSC notes, however, that this overall competitiveness must be maintained moving forward if the forecasted volumes are to materialize.

OSC uses data from reliable, consistent sources such as the IMF, Statistics Canada, the US Bureau of Economic Analysis, and the US Maritime Administration. It built an extensive and solid time series database as the foundation for the forecast. Where it uses inconsistent sources (e.g., traffic volumes from individual ports) it recognized this and addressed it to the extent possible.

3.2 Discussion

Choice of methodology. The first issue is whether OSC chose an appropriate methodology for the Port of Vancouver container forecast. In this case, we are not dealing with a new product or service, and considerable historical data exists, a quantitative methodology would be preferable over a qualitative approach. OSC appropriately chose a quantitative approach for this situation. Moreover, rather than conducting a simple time series and projection, OSC chose the more sophisticated causality modelling approach. They combined a top-down approach that assessed a broad range of important factors for the forecast to 2025, and assessed three economic/trade scenarios for the longer range portion of the forecast. This approach allowed for development of a baseline forecast, as well as high and low cases to provide a range of probable outcomes.

It is my opinion that this was an appropriate methodology for the Port of Vancouver container forecast.

Execution of methodology. The OSC forecasts were properly conducted. As discussed further below, I supplemented the OSC model with a risk-based forecast and found that the OSC results have a high degree of correspondence with the risk-based model results. While we more formally introduce the risk augmented Port of Vancouver container forecast in a later section, a few observations are offered here based on those results. The OSC base case closely corresponds to the most likely case in the risk augmented model, which is generally a good indication of forecast reasonableness. Further, the OSC high and low cases lie within the 10^{th} and 90^{th} percentiles of the risk augmented analysis, as shown later. This means that there is only about a 10% chance of a result above the high case or below the low case. It is thus my opinion that the OSC forecast gives a good range of the likely results that provides meaningful guidance for Port of Vancouver decision-making regarding the need for additional capacity.

Quality of data. OSC undertook an extensive data collection exercise. It used trustworthy data sources, and assessed the data to ensure to the extent possible that the data was consistent across years and ports. The Port of Vancouver demand data goes back to 1990, which allows for a long period over which changes in relative shares of the major ports can be observed. Other data does not go as far back, but are generally of sufficient length of time to ascertain trends. Unlike some other forecasts and analysis we have been asked to review, including academic studies, there are no obvious flaws in the database that are apparent. There is always a possibility of data errors but we find this data to generally meet the standard for port forecasting.

Understanding of important factors. The OSC forecast shows an understanding of local and global factors affecting the volume of containers that will move through the Port of Vancouver in the period under examination. The forecast takes into account expected GDP growth for specific regions that will

impact container flows, as well as factors that pose risks (or provide opportunities) for growth beyond that simply driven by GDP. It assessed the different hinterlands separately, and examined the whole supply chain competitiveness to/from these hinterlands from the competing ports, not just the ports themselves. This is a key issue: the degree of cost-competitiveness of the railways serving the Port of Vancouver would have a substantial impact on port traffic volumes. The OSC forecast also considered key trends and limitations to these trends (e.g., reaching a saturation point for certain inbound containerized goods; the increasing interest in reshoring/nearshoring). It takes into account the prices of key commodities, as well as new trade agreements such as the Trans-Pacific Partnership.

It is my opinion that the OSC forecast represents a good understanding of not only the factors affecting port volumes, but the various supply chains that connect the port to its markets.

Transparency of assumptions. OSC clearly states its assumptions and the rationale for the various scenarios it develops. OSC provides numerous tables providing the data used in the forecast and indicates sources.

3.3 Conclusion: A good standard and a reasonable forecast

The OSC forecast methodology meets a good standard and its forecasts are reasonable. It is my opinion that the OSC forecast meets the standard of a good forecasting methodology and a good result. Its use of a top down approach ensures that it must consider continent wide trends and developments. It is not narrowly focusing on trends at Port of Vancouver. Its data development is extensive, covers major relevant elements including what is happening at other ports, competitiveness in fees and charges and beyond that to supply chain competitiveness. Its forecast anticipates long term developments in terms of economic market maturity, technical change, changes in location of supply and demand, and potential for major shifts in geopolitical stability and attitudes toward trade.

4 Treatment of Risk in the OSC Forecast

The OSC forecast considers a number of major risk factors, including things such as long term economic stagnation and the potential for some nations to move toward trade protectionist policies. It incorporates these risk elements via specific assumptions for a small number of potential future long run scenarios. For the long run forecasts to 2050 it posits a small number of scenarios. This produces a range of potential future traffic outcomes (the lowest of which still posits significant growth in Port of Vancouver container traffic from roughly 3 million to 6 million TEUs).

In recent years the treatment of risk in forecasting has evolved to a) consider a wider range of risk factors including black swan (low probability but high impact events), b) to specify these factors with probability distributions, and c) to undertake a large number (typically 10,000) of potential scenarios. InterVISTAS refers to this probability based methodology as 'stochastic' forecasting.

There are several advantages to this augmented scenarios approach. First, it allows probabilities to be assigned to outcomes. The traditional risk approach used by OSC (which is also the method used by Transport Canada) posits high and low scenarios but with no probability of these being the outcomes – nor is there a probability of the base case as an outcome. Second, it allows probability ranges, such the central 50% probability band for traffic levels, or the 20%-80% band, etc. Third, it also allows addressing questions such as what is the probability that there will be no traffic growth or that traffic growth falls below the level needed to justify an expansion project.

InterVISTAS proposed to the Port of Vancouver, and it accepted and authorized complementing the core OSC forecast with richer consideration of risks, both in terms of the range of risk factors and the number of scenarios. The benefit of considering a greater range of risk factors is obvious. A greater number of scenarios allows considerations of situations where some things depress traffic and other do not.[3] It allows considerations of scenarios which depress traffic for several years followed by return to normal or even stimulative effects.

The InterVISTAS risk enhanced forecast of Port of Vancouver traffic is discussed in the next section.

[3] Low scenarios in the Transport Canada methodology typically contemplated multiple negative factors, such as lower GDP growth and higher fuel prices (sometimes a cause of lower GDP growth). While this is possible, there are also can be (and historically have been) cases of low GDP growth and low fuel prices (sometimes a consequence of low GDP growth).

5 Complementing the OSC Forecast with a Stochastic Risk Analysis

5.1 What do we mean by risk?

Risk in the context of traffic forecasting is not about the degree of danger an activity poses to human health or well-being. Risk refers to the chance that events will not go according to plan; that variations to or deviations from expected results will happen.

In 1921, economist Frank Knight defined risk as randomness in which events have measurable probabilities.[4]

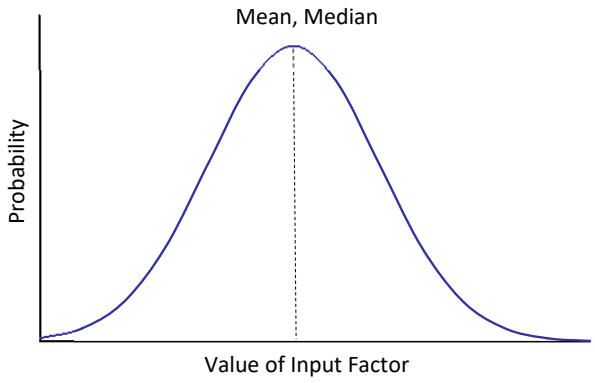
Probabilities may be measured either by deduction (using theoretical models) or induction (using the observed frequency of events). For example, statisticians can deduce the probabilities of the possible outcomes of a game of dice. Similarly, economists can deduce probability distributions for GDP growth based on historical data.

In forecasting, probabilities are generally not a single number but are a function that provides the likelihood of a range of potential outcomes for any activity. Probabilities tend to follow a number of distribution patterns.

The most widely known probability distribution is the “Normal” distribution. (This was originally called the Laplace-Gaussian distribution). This is the traditional bell curve showing the probability of the outcome of the event. The normal distribution has been widely used, and underlies much statistical theory, including the statistical properties of regression models.

The problem with the normal distribution is that any value, including very extreme values, can occur. For example, if the distribution describes the probabilities of Canadian GDP for next year, then if GDP is posited to follow a normal distribution there is some mathematical chance (very low but it is possible with a normal distribution) that it will be double this years’ GDP, an outcome which in practical terms seems highly unlikely. There is also the mathematical possibility with a normal distribution that GDP will be zero, or even negative.

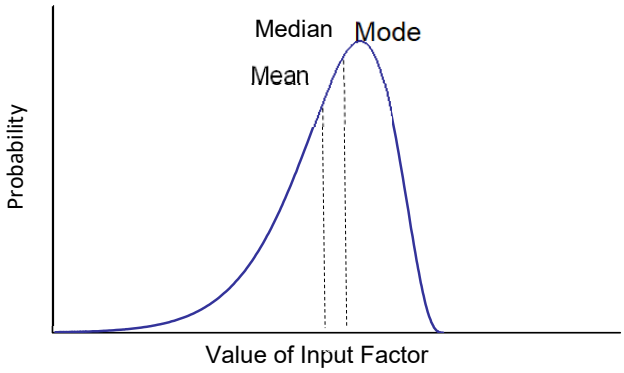
Example of a Normal Distribution



[4] Frank Knight was not the first to introduce the concept of risk. Risk is an age old concept. There are references to marine insurance in Hammurabi’s code with dates back to 1800 BC.

While the normal distribution has attractive mathematical statistical properties, when simulating things like future traffic levels at a port, it is desirable to prevent extreme values from occurring. One distribution that does this is a BetaPERT distribution.[5] The BetaPERT distribution is similar to a normal distribution in that it is single modal and starts from low probabilities of small outcomes, rising to the maximum probability of a more central outcome (technical is the 'sample mode' outcome), then declining to low probabilities of the highest outcomes. Unlike the normal distribution it is bounded and implausible extreme values are not allowed. The distribution can be symmetrical like the normal distribution, but can also be set up to be skewed in favour of higher or lower values, depending on what is appropriate. This distribution is often used in risk analysis to prevent extreme outcomes from occurring in randomly generated scenarios.

Example of a BetaPERT Distribution



5.2 Methodologies for incorporating risk analysis into forecasts

As with any projection of future activity, marine container traffic forecasts are subject to a degree of risk and uncertainty. The forecasts are based on underlying assumptions regarding economic growth, trade development, fuel prices, marine technology, etc. which will be developed from the best available intelligence and analysis. However, it is not possible to determine with certainty how these factors might vary over time and when certain events may occur; .e.g., the timing of recessions, trade wars, fuel shortages, etc. Furthermore, one-off events such as terrorism attacks and major natural disasters may have an impact on marine traffic (by affecting GDP growth or raising costs through additional security measures, etc.) but are impossible to predict when, or even if, they will happen.

The traditional approach to this issue in traffic forecasting is to supplement the Base or Most Likely case forecasts with high and low forecasts. This conveys that there is a degree of uncertainty in the forecast, and provides a rough range for likely outcomes.

An alternative approach to better understanding the range of possible future scenarios is to apply *quantitative risk analysis* to the forecast.

Quantitative risk analysis recognises that there are a number of key drivers of the forecast (economy, trade developments, fuel prices, etc.) and that each of these drivers has its own level of uncertainty or its own probability distribution. This type of risk analysis utilises the probabilities of these drivers to create a large number of potential scenarios. One scenario might be normal economic performance but with high fuel costs, growing trade protectionism and a terrorism event. Another might be weak economic performance and high fuel costs but with no terrorism event and growing trade liberalization. Typically, the quantitative forecasts will create thousands of such scenarios, each time randomly generating values for each of the forecast drivers. This is often referred to as Monte Carlo simulation.[6]

[5] This is a particular type of a general class of "Beta" distributions.
[6] The term "Monte Carlo" simulation is a term of art in statistical analysis. It is not intended to convey a sense that the analyst is gambling in terms of outcomes. The term merely reflects that outcomes in the

The real power of the Monte Carlo simulation lies in its ability to provide more meaningful statements regarding this range of possible forecast outcomes. Rather than produce just a single static outcome, the process can also provide a probability-weighted range of traffic outcomes and allow questions to be addressed, such as:

- What is the probability that container traffic growth will be less than 4% per annum over the next 5 years?
- What is the probability that container traffic at the port will exceed existing terminal capacity by 2025?
- What is the probability that container traffic will exceed 4 million TEUs by 2020?

The risk analysis considered the generalised economic and industry factors that apply to most ports, e.g., variability in economic growth, fuel prices, rates and charges, impact of a port-related terrorism attack, etc. The addition of the risk analysis still allows for the production of a most likely forecast by taking an average across all the scenarios.

5.3 The Stochastic Risk forecast model

Monte Carlo simulation (or the Monte Carlo method) is a computerized simulation technique which makes use of randomization and probability statistics to investigate problems involving uncertainty. Typically, it involves a computer model of a system or project (e.g., container traffic at a port) over time. The inputs to the model are specified as probability distributions instead of being fixed numbers or variables. For example, rather than traffic growth being set at X% per annum, it might be defined as having Normal (bell-curve) distribution with a mean of X% and a standard deviation of 1.0%. Using computer software, the model is run multiple times, each time randomly sampling from the input distributions, resulting in different outcomes each time. Often, the model will be run thousands or tens of thousands of times (known as iterations) and the results are collected from each run. Modelling the impact on a system or process of random variables that change over time and are not influenced is referred to as a stochastic process. The theory of stochastic processes is well established and is used in finance (e.g., modelling stock prices), project planning, engineering studies, traffic modelling, cancer radiation therapy, and telecommunications network design, among many other applications.

With enough iterations of the model, the output can demonstrate the range of possible outcomes and provide statistical estimates of the probabilities of various outcomes. Depending on the complexity of the model and input distributions assumed, the range of outcomes can be large and are not always linear. Expected or “most likely” values can also be generated.

Monte Carlo can be seen as a powerful “what-if” or scenario-generating exercise where every possible what-if or scenario is generated (within the confines of the model specification), including interactions between the various input factors. Another way of looking at it is that each iteration of the model represents one possible future for the system being modelled. By running the model thousands of times, the user can view whole sets of possible futures and assess which are most likely to occur; and identify areas of greatest downside or upside.

Selected risk factors affecting container traffic development at the Port of Vancouver and corresponding probability distributions were applied. The identification of these factors was a result of detailed research, stakeholder consultation, previous analysis and expert judgment. The risk factors are presented in the next section.

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future are uncertain, and considering a wide range of possible future outcomes can reveal the degree of risk in any particular future outcome.

Using these factors and distributions, forecasts were generated for 10,000 iterations of the Monte Carlo simulation. The results of this analysis are provided in section 6.5. The Monte Carlo risk model was developed by Inter*VISTAS* in the MS Excel platform combined with Visual Basic components. It is based on established quantitative risk analysis approaches used for financial analysis, insurance assessment, project planning, and safety assessment.[7]

5.3.1 Economic risk/opportunity factors

The following elements are included as risk/opportunity factors in the stochastic model:

- **CPA-TPP agreement.** The new proposed CPA-TPP agreement is enacted, boosting trade between Canada and its Asia-Pacific partners. We posit higher upside impacts to reflect additional gains should the US re-join the new TPP agreement.

- **Long-term global trade liberalization.** The world overcomes the current trade bumps emanating from the current US administration and continues on a path to a more liberalized global trade environment. Reduction of tariffs and elimination of trade barriers stimulate growth in demand across the Pacific.

- **Long-term global trade protectionism.** The world continues its recent steps towards a more protectionist global trade environment. Protectionist policies increase tariffs and costs associated with trade impacting demand for containerized goods across the Pacific. The impact is estimated from the difference in the pure economic forecast versus OSC's considered scenario forecasts and revised with Port of Vancouver input.

- **US-China trade war.** The US and China engage in a major trade war significantly impacting maritime volumes. The impact only affects US-destined imports and exports at Port of Vancouver. The impact of this event will be most severe in the early years of the trade war, with partial recovery occurring within five years.

- **Failure of NAFTA.** Political tensions result in the NAFTA trade agreement failing and being rescinded. A range of impacts is modelled, including: a loss of traffic due to a decline in the economic output of both Canada and the US due to higher tariffs and disruption to existing supply chains; and potential gains in Port of Vancouver TEUs as Canada focuses its trade efforts on major Asia-Pacific partners. Overall, however, the negative impacts are expected to outweigh the positive impacts, on average.

- **Changes in North American GDP levels.** Simulation of North American GDP is based on OSC forecasts and is used to generate simulated economic conditions for TEU imports. The effect on annual TEU throughput is based on the difference between risk-based projections of annual GDP growth rates versus OSC's Base Case assumptions. GDP variations are translated into TEU throughput through GDP elasticities developed by OSC. This variation takes place every year.

- **Changes in Asian GDP levels.** Simulation of Asian GDP is based on OSC forecasts and is used to generate simulated economic conditions for TEU exports. The effect on annual TEU throughput is based on the difference between risk-based projections of annual GDP growth rates versus OSC's Base Case assumptions. GDP variations are translated into TEU throughput through GDP elasticities developed by OSC. This variation takes place every year.

[7] See, for example, Risk Analysis: A Quantitative Guide, D. Vose, 3rd Edition, 2007, and Probabilistic Risk Analysis: Foundations and Methods, T. Bedford and R. Cooke, 1st Edition, 2001.

- **Regional recession in North America.** A regional recession affecting North America occurs, impacting simulated GDP and import TEU demand. This risk impacts simulation of GDP, *not* TEUs directly. The impact of this event is considered transitory, with GDP recovery the next year.

- **Regional recession in Asia.** A regional recession affecting Asia occurs, impacting simulated GDP and export TEU demand. Again, this risk impacts simulation of GDP, *not* TEUs directly. The impact of this event is considered transitory, with GDP recovery the next year.

- **Global recession**. A global recession (similar to the 2008/09 recession) occurs, resulting in a significant decrease in both North American and Asian GDP growth. The two years of slower economic growth follow the immediate recessionary impact, followed by two years of recovery.

- **Annual fuel price volatility.** Annual volatility of fuel/oil prices is simulated every year, with an impact on shipping costs and consumer demand. The impact on TEUs is calculated based on an assumed -0.05 price elasticity related to fuel costs. This variation takes place every year.

- **Major fuel price spike/dip.** There is potential for major spikes or dips in the price of oil and fuels similar to what happened in 2008 helping trigger the subsequent recession. These price spikes are assumed to be transitory and of significantly greater magnitude than annual price variation.

5.3.2 Demographic and social risk/opportunity factors

- **Increasing social and environmental concerns drive near-shoring.** Increased public concerns and awareness of environmental and social implications of long-distance trade, product/manufacturing safety, and human rights abuses results in a reduced demand for goods from the Asia-Pacific region in favour of near-shoring within the Americas. The impact of this event is considered permanent.

5.3.3 Technology risk/opportunity factors

- **New technologies reduce maritime shipping costs.** Major adoption of new technologies reduces maritime shipping costs and overall costs of goods to consumers and manufacturers. New technologies could include adoption of blockchain and wide adoption of electronic waybills. The impact is based on estimated reduction in the cost of import/export goods arising from a decrease in shipping costs as administrative, financial and overhead costs are reduced. The impact of this event is considered permanent.

5.3.4 Supply Chain risk/opportunity factors

- **Bankruptcy of a major shipping line.** One of the major trans-Pacific shipping lines goes bankrupt, temporarily impacting Port of Vancouver container volumes. The impacts are based on disruption of services for a 6-month period for carriers of varying market share. Due to oversupply in the market, the impact on TEUs is expected to be felt for approximately half a year and a full recovery is expected within two years. The impact of this event is considered transitory.

- **Labour action at a competing port.** Labour action at a competitor port leads to a temporary increase in TEU throughput at Port of Vancouver as containers are re-routed. TEU volumes return to normal within a year. The impact of this event is also considered transitory.

5.3.5 Competition risk/opportunity factors

- **Port of Vancouver gains market share against U.S. Pacific Northwest ports.** The Port increases its market share of Pacific Northwest TEU volumes. This effect captures a multitude of potential competitive impacts such as lack of capacity at Pacific Northwest competitor ports,

increasing cost competitiveness at Port of Vancouver, and improved rail links to hinterland. The impact of this event is considered permanent.

- **Port of Vancouver loses market share against U.S. Pacific Northwest ports.** The Port loses market share of Pacific Northwest TEU volumes to competing ports. This effect incorporates similar factors to the previous impact but with negative effects at Port of Vancouver. The impact of this event is considered permanent.

- **Shift in traffic flows to eastern Canada and southern/eastern U.S. markets.** A systematic change in the flows of goods to Eastern Canada and the Eastern/Southern US occurs, shifting the balance of TEUs between the Pacific and Atlantic/Gulf ports. This risk factor simulates a change in market share compared to OSC's Base Case assumptions of continuing status quo trade balance between Pacific and Atlantic/Gulf ports to the North American hinterland. The shift could occur in either direction (i.e., west coast ports could gain, or lose, traffic relative to Atlantic and Gulf of Mexico ports. The impact of this event is considered permanent.

- **Shift in traffic flows to North American markets from northern to southern west coast ports.** A systematic change in the flow of goods to North America occurs, shifting the balance of TEUs between Pacific Northwest ports and California ports. This risk factor simulates a change in market share compared to OSC's Base Case assumptions of continuing status quo. Again, this shift could occur in either direction.

5.3.6 Geo political risk/opportunity factors

- **War in the Middle East impacts shipping through the Suez Canal.** A military conflict emerges in the Middle East forcing the closure of the Suez Canal and/or the Red Sea and Gulf of Aden. Closure of this vital sea lane causes increased TEU volumes to the North American Pacific Coast as East Coast destined goods will incur unacceptably long transit times around Cape Horn. When the conflict ends, volumes return to normal, and the effects are gone within two years. The impact of this event is considered transitory.

- **War in Asia.** A military conflict breaks out in Asia disrupting shipping lanes and increasing insurance premiums on maritime transport. Asia-Pacific to North American trade declines due to the conflict. Again, when the conflict ends, volumes return to normal, and the effects are gone within two years. The impact of this event is considered transitory.

- **Closure of Panama Canal.** The Panama Canal is closed for an extended period of time, potentially due to military conflict, natural disaster, or government action. A significant majority of Asia to Eastern North America container traffic will be diverted through Pacific West Coast ports, with Port of Vancouver receiving a significant increase to its volumes. After the initial impact, traffic volumes are expected to return to normal within five years. The impact of this event is considered transitory.

5.3.7 Black swan events

- **Natural disaster closes key Asian port.** A major natural disaster at a key export port in Asia occurs, reducing throughput and capacity. Supply chain interruptions have negative impact on Pacific West Coast ports. After the initial impact, traffic recovers within a year. The impact of this event is considered transitory.

- **Natural disaster closes a competing North American port.** A major natural disaster at a North American West Coast port leads to container flows diverting to Port of Vancouver. After the initial impact, traffic recovers within a year. The impact of this event is considered transitory.

5.4 Results from the stochastic forecasting model

Incorporating the above noted risk/opportunity factors into the stochastic forecasting model gives the following results:

InterVISTAS Risk Analysis of VFPA TEU Throughput							
Year	5th Percentile	10th Percentile	25th Percentile	Most Likely	75th Percentile	90th Percentile	95th Percentile
2015 (actual)				*3,054,500*			
2016	2,852,900	2,983,100	3,101,700	3,172,800	3,228,800	3,402,200	3,479,200
2017	2,967,100	3,082,600	3,264,600	3,370,900	3,521,900	3,681,300	3,773,600
2018	3,118,000	3,243,300	3,432,000	3,574,100	3,776,000	3,938,000	4,068,100
2019	3,256,300	3,392,700	3,608,600	3,786,500	4,014,700	4,210,500	4,385,300
2020	3,421,900	3,569,500	3,801,500	4,019,500	4,255,200	4,499,600	4,709,700
2021	3,566,400	3,721,300	3,980,300	4,228,100	4,489,400	4,781,900	5,002,000
2022	3,703,700	3,881,100	4,156,500	4,431,700	4,718,300	5,057,000	5,281,100
2023	3,803,900	3,984,400	4,276,700	4,573,300	4,880,300	5,247,500	5,495,700
2024	3,901,900	4,092,700	4,400,200	4,719,700	5,060,700	5,450,800	5,699,400
2025	3,992,700	4,194,500	4,522,500	4,863,500	5,229,800	5,643,200	5,927,700
2030	4,400,300	4,665,600	5,075,400	5,515,400	5,998,900	6,536,900	6,927,900
2035	4,765,700	5,058,700	5,561,700	6,099,400	6,725,100	7,433,600	7,868,500
2040	5,061,300	5,397,500	5,991,800	6,674,600	7,435,600	8,248,700	8,787,500
2045	5,323,700	5,708,400	6,368,500	7,148,400	8,048,500	9,013,900	9,674,900
2050	5,487,600	5,903,800	6,670,200	7,564,100	8,608,100	9,689,700	10,430,700
5-Year CAGRs							
2015-2020	2.3%	3.2%	4.5%	5.6%	6.9%	8.1%	9.0%
2020-2025	3.1%	3.3%	3.5%	3.9%	4.2%	4.6%	4.7%
2025-2030	2.0%	2.2%	2.3%	2.5%	2.8%	3.0%	3.2%
2030-2035	1.6%	1.6%	1.8%	2.0%	2.3%	2.6%	2.6%
2035-2040	1.2%	1.3%	1.5%	1.8%	2.0%	2.1%	2.2%
2040-2045	1.0%	1.1%	1.2%	1.4%	1.6%	1.8%	1.9%
2045-2050	0.6%	0.7%	0.9%	1.1%	1.4%	1.5%	1.5%
Long-Term CAGR							
2000-2015				6.6%			
2015-2050	1.7%	1.9%	2.3%	2.6%	3.0%	3.4%	3.6%

The most likely result is shown in the middle (unshaded) column. The columns on either side show the range within which the result will fall with a probability of 50% (25th to 75th percentile), of 80% (10th to 90th percentile) and 90% (5th to 95th percentile). For example, the most likely outcome is that the Port of Vancouver will serve just over 4.86 million TEUs in 2025. There is a 50% probability that the port will serve between 4.52 million and 5.23 million TEUs in 2025. There is a 10% probability that the port will serve less than 4.19 million TEUs, and a 5% chance that it will serve 5.93 million or more TEUs.

I summarize the OSC results below for comparison purposes.

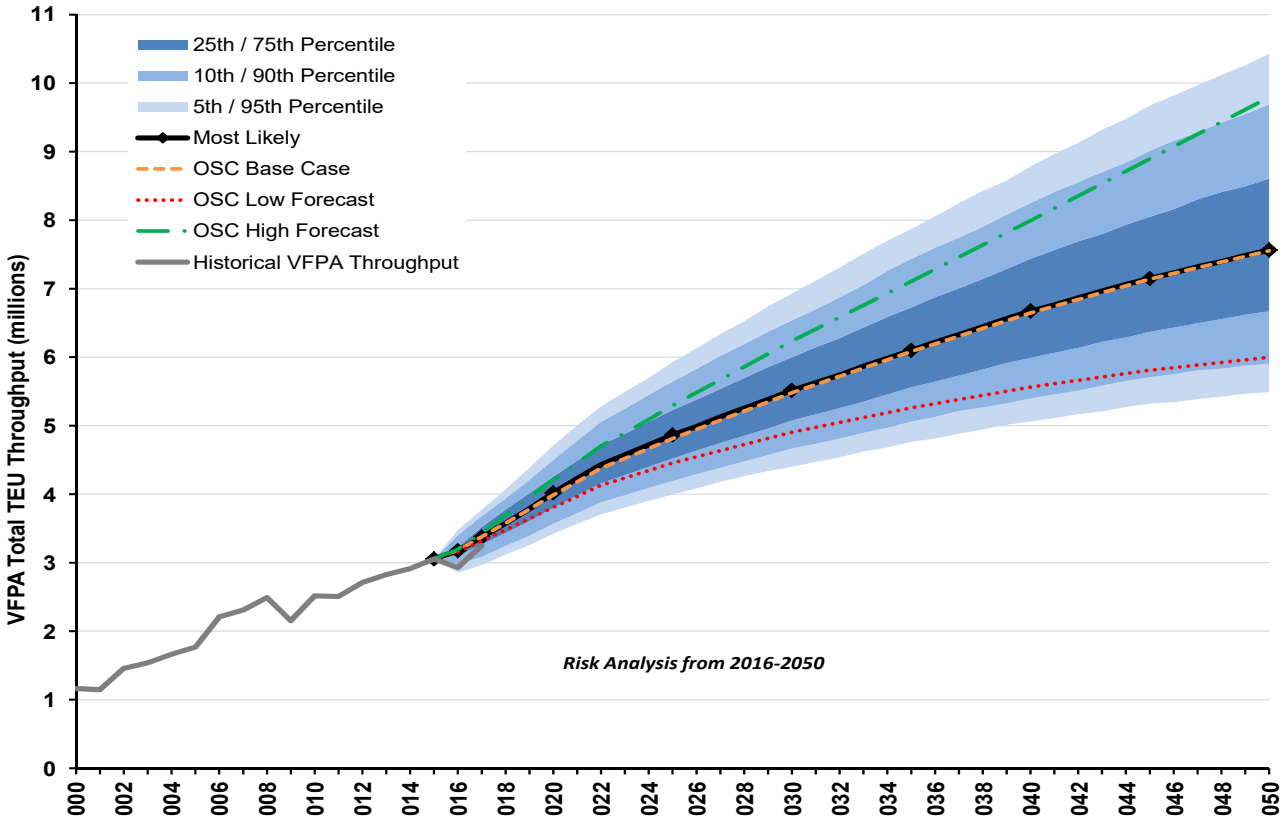
OSC VFPA TEU Forecast			
Year	Low	Base Case	High
2015 (actual)		*3,054,500*	
2016	3,177,100	3,177,100	3,054,500
2017	3,161,100	3,379,900	3,192,800
2018	3,317,400	3,577,400	3,435,400
2019	3,481,600	3,780,500	3,693,700
2020	3,643,700	3,986,700	3,950,100
2021	3,807,700	4,178,800	4,212,100
2022	3,966,000	4,380,200	4,450,700
2023	4,131,000	4,520,200	4,702,900
2024	4,236,100	4,664,300	4,892,300
2025	4,343,700	4,812,600	5,089,000
2030	4,904,700	5,479,400	6,233,700
2035	5,259,900	6,082,500	7,108,000
2040	5,563,800	6,645,300	7,994,700
2045	5,809,800	7,139,800	8,894,800
2050	5,998,700	7,552,700	9,793,300
5-Year CAGRs			
2015-2020	3.6%	5.5%	5.3%
2020-2025	3.6%	3.8%	5.2%
2025-2030	2.5%	2.6%	4.1%
2030-2035	1.4%	2.1%	2.7%
2035-2040	1.1%	1.8%	2.4%
2040-2045	0.9%	1.4%	2.2%
2045-2050	0.6%	1.1%	1.9%
Long-Term CAGR			
2000-2015		6.6%	
2015-2050	1.9%	2.6%	3.4%

Looking at the 2050 results, the OSC base case result of 7.55 million TEUs is very close to the stochastic model's forecast of 7.56 million TEUs. As I noted earlier, in a good forecast model generally the traditional base case will correspond very closely to the most likely forecast in the stochastic model. The 2050 high case in the OSC forecast falls just outside the 90th percentile of the stochastic model, and the 2050 low case falls between the 10th and 25th percentile. As noted previously, this asymmetric result is to be expected.

As previously noted, I plotted the results of the stochastic model and superimposed the OSC base, high and low case results onto the chart. I show the chart again here for convenience. This chart illustrates that the OSC forecast is consistent with the results of my stochastic risk-based forecast.

Inter*VISTAS*' Risk Analysis of OSC Forecast for VFPA TEUs

25 May 2018

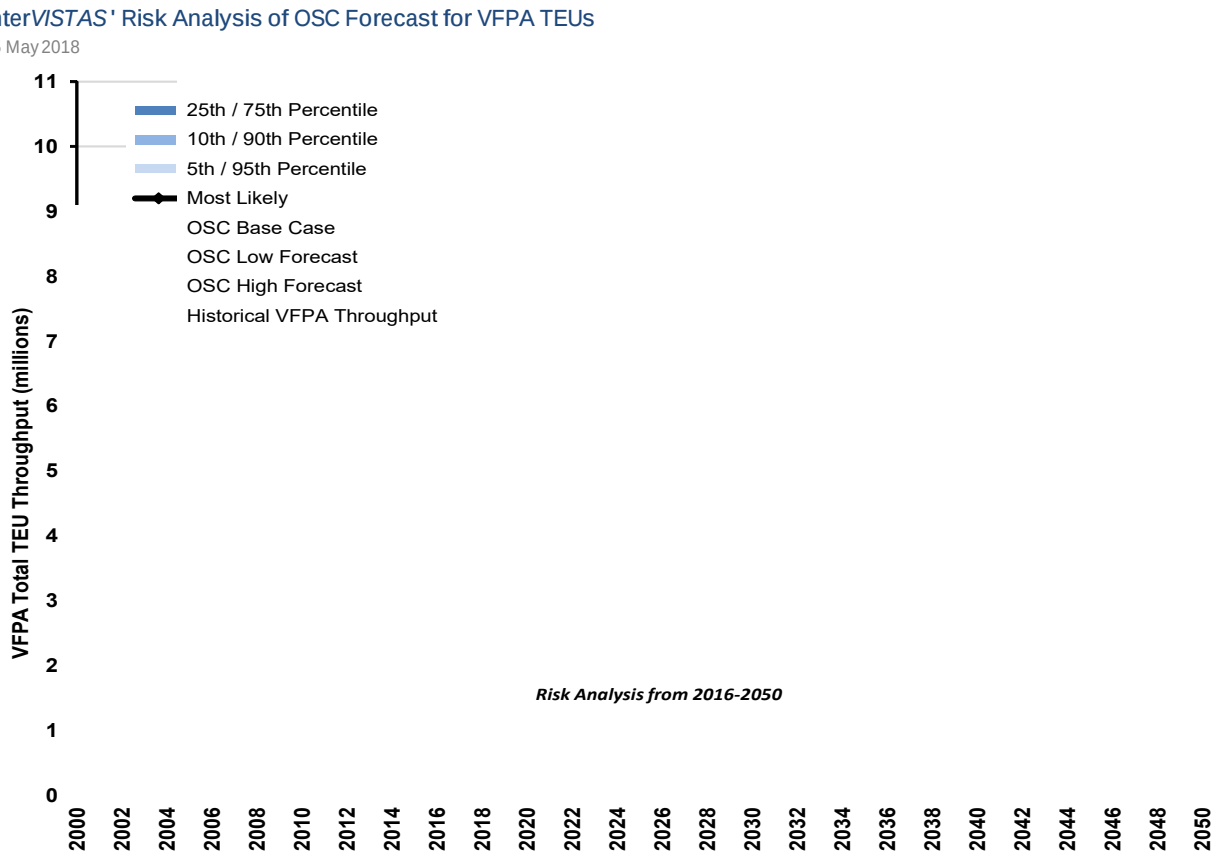


6 Conclusion and Opinion

It is my opinion that the OSC forecast meets the standard of a good forecasting methodology and provides reasonable forecasting results. Its use of a top down approach ensures that it must consider continent wide trends and developments. It is not narrowly focusing on trends at Port of Vancouver. Its data development is extensive, covers major relevant elements including what is happening at other ports, competitiveness in fees and charges and beyond that to supply chain competitiveness. Its forecast anticipates long term developments in terms of economic market maturity, technical change, changes in location of supply and demand, and potential for major shifts in geopolitical stability and attitudes toward trade.

OSC used an appropriate methodology, executed the methodology well, developed an extensive database to base the forecast on and exhibited an understanding of the key broader issues that could impact the number of containers passing through the Port of Vancouver.

I augmented the OSC base/high/low case approach with a risk-based forecasting approach based around the OSC base case in order to be able to ascertain probabilities of alternative volumes. This approach allows for a greater range of risk factors that could influence the expected results, and simulates 10,000 possible scenarios. Augmenting the OSC forecast, we see that the OSC high case and low case fall within the 10th to 90th percentile of likely outcomes.



List of Abbreviations

BEA	U.S. Bureau of Economic Analysis
GDP	Gross Domestic Product
IMF	International Monetary Fund
OECD	Organization for Economic Co-operation and Development
OSC	Ocean Shipping Consultants
PNW	Pacific Northwest

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