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Eardley, Matthew Peter

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Quantitative Analysis of Demurrage Risk associated with a Rwandan Cement Producer's Virtual Warehousing

Eardley, Matthew Peter
(Student number: 1891286)

Supervisor: Dr Buhrmann, Joke

ABSTRACT

CIMERWA's virtual warehouse (VW) in Kigali, Rwanda, supports the pre-emptive dispatch of product toward the epicentre of its demand for delivered cement. This practice yields many benefits. Expansion both in terms of the number of VWs and vehicles dispatched to VWs would increase these positive effects. However, this exercise is also fraught with uncertainty, as customer order behaviour is variable. If a truck arrives at a VW location, it must await an order, sometimes overnight, which may result in a demurrage charge being incurred. CIMERWA requires a stronger understanding of the risk of demurrage associated with each type and extent of expansion of its VW model prior to implementation.

A mathematical model was developed to provide this insight by both determining the optimal locations for VWs if more were to be added to the network, as well as test the designs under different degrees of aggression when numbering of trucks to be dispatched. An optimization model was built using an Advanced Planning System to position VWs such that the market reach of the network was maximized. It was found that 50.94% of CIMERWA's demand could be satisfied via a single optimally placed VW, while 87.43% of its total demand could be reached pre-emptively via the network if five VWs were used.

An Excel Monte Carlo simulation model was subsequently used to test the five optimal networks using different planning methods. A planning method was defined as the combination of the strength grade of cement used to load VW-bound vehicles and two variables that accounted for the uncertainty inherent in the moving average forecast that was an input to the simulated heuristic used by the office to decide on the number trucks to dispatch. Relationships between each of the planning method parameters and the number of demurrage charges incurred annually were determined for each network. Other system performance metrics, including the reduction of waiting days spent by customer, were also calculated for each scenario and used to discuss the dynamics governing the behaviour of the operation and the merits of each scenario.

Simulation data was then used to develop recommendations according to postulated minimum annual improvements in lead time days saved. It was found that a saving of 500 days per year would come at an average cost of nine demurrage charges if a single VW and forecast factor of safety of 0.2 was used. Using the same network, a factor of safety of 0.4 would satisfy a saving threshold of 1000 days while incurring

51 charges on average. The three-VW network would require a factor of safety of 0.6 to be used to reach the threshold performance of 2000 days saved with a mean of 220 demurrage charges. A factor of 0.8 would be needed in conjunction with four VWs to achieve the threshold of 3000 days, which would incur an average of 645 charges annually. Should management require more than 3810 days of waiting time to be saved, 32.5N strength cement would have to be substituted with 42.5N cement so that VW-bound trucks could deliver to customers who order either variant. The use of 42.5N cement in conjunction with five VWs would achieve a saving of over 4000 days, with 1367 charges incurred.