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Manuscript

# A THEORETICAL FRAMEWORK FOR THE EVALUATION OF COMPETITION BETWEEN CONTAINER TERMINAL OPERATORS*

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# Abstract

This paper presents a generally applicable framework for the analysis of potential competitive strategies and associated expected payoffs in the container terminal industry. The framework is based on the integration of Bowley's linear model of aggregate demand of product differentiation with Porter's "Diamond" model. It focuses on the number of containers handled, prices charged and profits earned to analyse a variety of strategies that could be employed by container terminal operators to enhance their competitive position. The findings suggest that strategies to build complementary relationships and stimulate greater demand are more desirable than alternatives because they generate benefits that accrue to the entire industry. Conversely, strategies that are intended to raise entry barriers, employ strategic pricing mechanisms and/or involve collusion are found to lead to the formation of insular clusters and retard competitive advantage in the long run.



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## 1. Introduction

The vast majority of international trade, both in tonnage and value terms, continues to be carried in waterborne transport. As a result, the competitiveness of a port exerts an important influence on an entire region's socio-economic viability and propensity for growth and development. In 2000, seaborne trade reached 5.9 billion tons, an increase of 19% over 1997 (UNCTAD, 2002). In the same period, as Table 1 shows, the share of merchandise trade in the ten largest trading nations/regions rose by 16.3% to reach 7.3 trillion USD.

**INSERT TABLE 1**

Every port serves a hinterland which, according to van Klink and van der Berg (1998) can be defined as the "…*continental area of origin and destination of traffic flows through a port (i.e.) the interior region served by the port*." The irrefutable fact, however, that every port of origin requires a port of destination implies that a port's hinterland could be extended to include an area covered by what may be considered to be the hinterland of (an)other port(s).

Haezendonck and Notteboom (2002) noted that a port's productivity, its actual and potential cargo generating ability, its reputation and reliability, together with the accessibility of a port's hinterland, were all critical factors in determining a port's competitiveness. Robinson (2002) also suggests that ports form parts of value-driven supply chains that cross and link hinterlands and that, in consequence, it is vitally important for the providers of port or terminal services to offer sustainable value to their users as compared against competing value-driven supply chains that encompass different

ports or terminals. Hence, through the transmission medium of the supply chain systems that incorporate a particular port as a node, any efficiency gains generated within that port (and the enhanced competitiveness that this produces) yields cascading benefits for the hinterlands of both origin and destination ports (Haynes, Hsing and Stough, 1997).

A comprehensive structure of the determinants of a port's competitiveness based on Porter's "Diamond" model (1990) was summarised in the framework provided by Rugman and Verbeke (1993). Using Porter's hypothesis, it could be said that firms, rather than ports, compete in international markets. In this context, the term 'firm' refers to the container terminal operators that work within any given port. Rugman and Verbeke (1993) found six determinants that were deemed to influence the competitive advantage of terminal operators. These were:

- *factor conditions* - a port's position in respect of its input factors of production;
- *demand conditions* - the underlying nature of the demand for the port's services that it offers;
- *related and supporting industries* - the presence or absence of internationally competitive suppliers and port-related industries located either within the confines of the port itself or within its hinterland;
- *firm strategy, structure and rivalry* - the conditions influencing the creation, organisation, management and rivalry of companies within the port;
- *chance events* - developments, circumstances or happenings that are beyond the control of the container terminal operators within the port, and;
- *role of the government* – the level and form of support, or otherwise, for the port sector in general and for the specific port in particular

The corollary of the analysis by Rugman and Verbeke (1993) is that container terminal operators within a port should capitalise on knowledge of these determinants to gain and sustain a competitive advantage by seeking to expand and entrench the captive hinterland of the port, as well as specifically their own customer base within this hinterland. Simultaneous attempts should be made to erode the customer base of their competitors (that could be located either within the same, or other, ports).

The wide spectrum of entities with which ports interact can be seen in the great diversity of industry players that are associated with their various objectives, tools and possible impacts (Heaver *et al.*, 2000). However, the list of potential interaction could be extended beyond simply the players, strategies, objectives and payoffs identified by Heaver *et al* (2000).

In an effort to reap both economies of scale and scope, there has been a recent spate of horizontal and vertical integration within the transport industry. The increasing bargaining power of buyers and suppliers that this trend has brought about, together with the footloose nature of cargo (i.e. the relative lack of customer loyalty amongst port choice decision makers) has prompted Notteboom and Winkelmans (2001) to propose that competitive advantage based on unique and resilient core competencies should be developed.

Given this situation, the ultimate aim of this paper is to analyse a range of available generic competitive strategies from the perspective of container terminal operators. The strategies analysed are based on insights drawn from a general framework for

competition in an oligopolistic setting and are analysed within an integrated framework that utilises the most salient features of Bowley's product differentiation model (1924) and the "Diamond" model of Porter (1990).

Section two of the paper reviews various models of oligopolistic competition, while the formal analytical framework is presented in section three. This framework will then be used to evaluate the impact of various competitive strategies in section four. Conclusions are drawn in section five.

## 2. Literature Review

Numerous studies have been undertaken to evaluate port competitiveness and the impact of port competition in the container terminal industry. A significant amount of this research effort has been dedicated to the study of port competitiveness and competition through approaches revolving around routing strategy and the efficiency of transportation networks, port productivity, and the consideration of shipper requirements (see Frankel, 1999; Notteboom *et al*., 2000; Baird, 2002; Cullinane, 2002; De and Ghosh, 2002; Haralambides *et al*., 2002; Robinson, 2002; Zeng and Yang, 2002; Luo and Grigalunas, 2003; Sanchez *et al*., 2003; Tiwari *et al*., 2003; Veldman and Bückmann, 2003; Yap and Lam, 2004).

Cluster analysis (De Langen, 2002), shift-share analysis (Notteboom and Winkelmans, 2001), value added concepts (Haezendonck, Coeck and Verbeke, 2000), the game-

theoretic approach (Flor and Defilippi, 2003), and the marginal cost pricing approach (Haralambides, 2002) have all been applied to evaluate port competitiveness.

The structure of the container terminal operating industry is generally characterised in terms of one dominant player within a port, plus a few other smaller operators. The veracity of this generalisation can be gleaned from Table 2, which shows the share of containers handled by the largest terminal operator within the world's major container ports.

**INSERT TABLE 2**

In spite of having one dominant terminal operator in most of the major container ports, overlapping hinterlands has meant that operators increasingly have to compete not only with other operators located within the same port, but also with operators located in other ports (Cullinane and Khanna, 2000; van de Voorde and Winkelmans, 2002). The higher degree of interdependence among these terminal operators creates a situation of oligopolistic competition where they can either engage in intense competition or cooperate to maximise returns (Shepherd, 1997). A wide range of behaviour can result from oligopoly situations due to the extensive number of permutations possible in the structure–conduct–performance paradigm encapsulated by Scherer (1970) that is defined by an indeterminate outcome (von Neumann and Morgenstern, 1944; Bain, 1956; Chamberlain, 1962).

Theoretical research in this field can be characterised mainly as that based primarily on quantity (Cournot, 1838) and that on price (Bertrand, 1883). Cournot's original quantity-setting model has since been expanded to account for limiting behaviour (Ruffin, 1971),

static game-theoretic considerations (Friedman, 1986; Gibbons, 1992), conjectural variations (Bramness, 1979), cooperation (Bresnahan and Salop, 1986), product differentiation (Bowley, 1924; Shubik and Levitan, 1980), and capacity constraints (Kreps and Scheinkman, 1983; Maggi, 1996). Kreps and Scheinkman (1983) and Maggi (1996) also developed behavioural models where capacity constraints exist in Bertrand's price-setting situation. Other methods used to analyse oligopolistic competition included uncertain demand (Klemperer and Meyer, 1988), spatial differentiation (Hotelling, 1952; Economides, 1984; Shaked, 1982) and income distribution (Shaked and Sutton, 1982).

This great variety of available methodologies and approaches all come with their respective strengths and deficiencies. Nonetheless, the model that is finally selected must allow for the salient attributes that characterise the oligopolistic competition that prevails in the container terminal industry. Potentially, this form of competition may exist within a single port, but certainly does exist within the overlapping hinterlands that have become a fundamental characteristic of the contemporary ports industry.

One such model is Bowley's linear model of aggregate demand and product differentiation (Bowley, 1924). With relative ease, the model can be used to distil the key implications of, or likely competitive outcomes from, a variety of strategies that may be adopted. The model can also be expanded to cater for cooperative behaviour, capacity constraints and a cost component. Herein, the Bowley model is melded with Porter's "Diamond" model (Porter, 1990) to produce a framework for the analysis of the strategies employed by container terminal operators to enhance their competitive position.

## 3. A Framework for Analysing Container Port/Terminal Competition

Consider Bowley's model of product differentiation under a simultaneous quantity setting for two container terminal operators. Total container throughput in terms of Twenty-foot Equivalent Units (TEUs) handled in the market would be: $Q = q_1 + q_2$. The linear inverse demand functions being:

$$P_1 = a - b(q_1 + \theta q_2) \quad (1)$$

and

$$P_2 = a - b(\theta q_1 + q_2) \quad (2)$$

$$....for\ P_1, P_2, a, b > 0,$$

…where $q_1$ denotes the TEUs handled by container terminal operator 1 ($TO_1$);
$q_2$ denotes the TEUs handled by container terminal operator 2 ($TO_2$);
$P_1$ denotes the price charged by $TO_1$;
$P_2$ denotes the price charged by $TO_2$; and
$\theta$ denotes the coefficient of product differentiation where: $-1 \leq \theta \leq 1$ and:

| | | |
|---|---|---|
| | $\theta = 1$ | $\Rightarrow$ TEUs handled by $TO_1$ and $TO_2$ are perfect substitutes; |
| | $0 < \theta < 1$ | $\Rightarrow$ TEUs handled by $TO_1$ and $TO_2$ are substitutes; |
| | $\theta = 0$ | $\Rightarrow$ TEUs handled by $TO_1$ and $TO_2$ are independent in demand; |
| | $-1 < \theta < 0$ | $\Rightarrow$ TEUs handled by $TO_1$ and $TO_2$ are complementary in demand; |
| and | $\theta = -1$ | $\Rightarrow$ TEUs handled by $TO_1$ and $TO_2$ are perfect complements. |

Profits for $TO_1$ and $TO_2$ are thus represented by:

$$\pi_1 = aq_1 - bq_1^2 - b\theta q_1 q_2 - c_1 q_1 \quad (3)$$

and

$$\pi_2 = aq_2 - bq_2^2 - b\theta q_1 q_2 - c_2 q_2 \quad (4)$$

…where $c_1$ and $c_2$ denote the unit cost of supplying the product or service for $TO_1$ and $TO_2$ respectively, with $a > c_1, c_2$. The cost component can be further distinguished between fixed cost (denoted by the symbol "*F*") and variable cost elements (denoted by the symbol "*c*"). For simplicity, we consider the case where all costs are deemed to be variable.

Container terminal operators are assumed to maximise profits. Hence, the best-response functions under the first-order condition to maximise $\{\pi_1, \pi_2\}$ with respect to $\{q_1, q_2\}$ are:

$$q_1 = \frac{a - c_1}{2b} - \frac{\theta q_2}{2} \qquad \text{Reaction Function of } TO_i\ (RF_1) \qquad (5)$$

$$\& \qquad q_2 = \frac{a - c_2}{2b} - \frac{\theta q_1}{2} \qquad \text{Reaction Function of } TO_2\ (RF_2) \qquad (6)$$

…with the second-order conditions for profit maximisation being: $\frac{\partial^2 \pi_1}{\partial q_1^{\ 2}} < 0$ and $\frac{\partial^2 \pi_2}{\partial q_2^{\ 2}} < 0$. The equilibrium quantity of TEUs handled, prices charged and profits earned by $TO_1$ and $TO_2$ are therefore:

$$q_1^* = \frac{a(2-\theta) - 2c_1 + c_2\theta}{b(2-\theta)(2+\theta)} \qquad \& \qquad q_2^* = \frac{a(2-\theta) - 2c_2 + c_1\theta}{b(2-\theta)(2+\theta)}; \qquad (7)$$

$$P_1^* = \frac{a(2-\theta) + c_1(2-\theta^2) + c_2\theta}{(2-\theta)(2+\theta)} \qquad \& \qquad P_2^* = \frac{a(2-\theta) + c_2(2-\theta^2) + c_1\theta}{(2-\theta)(2+\theta)}; \qquad (8)$$

$$\pi_1^* = \frac{1}{b}\left[\frac{a(2-\theta) - 2c_1 + c_2\theta}{(2-\theta)(2+\theta)}\right]^2 \qquad \& \qquad \pi_2^* = \frac{1}{b}\left[\frac{a(2-\theta) - 2c_2 + c_1\theta}{(2-\theta)(2+\theta)}\right]^2 \qquad (9)$$

Cournot's equilibrium for product differentiation in the case for two terminal operators can thus be represented by figure 1 where:

$a$ denotes a coefficient related to demand
$b$ denotes a coefficient related to demand
$c_i$ denotes the variable costs of $TO_i$
$q_i$ denotes the container throughput of $TO_i$
$\pi_i$ denotes the profit of $TO_i$
$\theta$ denotes the demand relationship between the different $TO_i$
$P_i$ denotes the price charged by $TO_i$

**INSERT FIGURE 1**

For $n$ ports, the inverse demand function for $TOi$ ($i = 1,...n$) becomes:

$$P_i = a - b\left(q_i + \sum_{j=1}^{n} \theta_{ij} q_j\right) \qquad \text{where } i \neq j \text{ for } i,j = 1,...,n \tag{10}$$

…and the reaction function of $TO_i$ becomes:

$$q_i = \frac{a - c_i}{2b} - \frac{\sum_{j=1}^{n} \theta_{ij} q_j}{2} \tag{11}$$

Solving for the reaction functions will yield the equilibrium output, prices and profits for each container terminal operator. For the general case, we can include the following variables:

$n$ denotes the number of terminal operators ($TO_i$)
$F_i$ denotes the fixed costs of $TO_i$

The six determinants proposed in Porter's model could either assist in the creation and sustenance of competitive positions enjoyed by container terminal operators or, alternatively, stifle and mitigate them (Porter, 1990). The model also stresses that the rate of upgrading is contingent on the weakest link and that individual companies play the most crucial role in building higher-order competitive advantages in an innovation-driven economy. Combining Porter's "Diamond" model with Bowley's model of product differentiation presents one way in which competitive advantages can be quantified, measured and analysed in a holistic manner. Table 3 illustrates how these determinants can be applied to the container terminal industry. The two models can be further summarised into a general framework presented in figure 2 for analysing and assessing competition between container terminal operators.

**INSERT TABLE 3**

**INSERT FIGURE 2**

The framework presented in figure 2 offers a means of ascertaining the impact of competitive advantage. In the following section, this framework will be utilised to analyse the impact of a number of potential strategies that may be used by container terminal operators to advance their competitive position.

## 4. Competitive Strategies for Container Terminal Operators

Container terminal operators, whether run by private or public entities, stand at the forefront of competition between container ports. They have at their disposal a variety of commercial and non-commercial tools to advance their competitive advantage. The framework developed in section three will be used to demonstrate the impact of some common strategies used by container terminal operators for such purposes. A theoretical scenario of two competing container terminal operators is used to exemplify the effectiveness of these strategies in terms of the number of TEUs handled, prices charged and profits earned.

*Strategy 1: Differentiate Demand*

Container terminal operators can boost their competitive position by pursuing the generic strategy of differentiation. Applying the model of product differentiation developed in section three, then in the case of two terminal operators, figure 3 shows the possible solutions, E1 to E5, that can be obtained for all possible product differentiation scenarios, as defined by: $-1 \leq \theta \leq 1$.

**INSERT FIGURE 3**

Without any differentiation of the products and services offered by both container terminal operators, the equilibrium solution is E1 where $\theta = 1$. This coincides with Cournot's solution in figure 1. The presence of differentiation, i.e. $0 < \theta < 1$, will result in a locus of solutions shown by the emboldened line identified as E2. The greater the degree of differentiation (i.e. as $\theta \rightarrow 0$), solutions lie closer to E3 than to E1. For $\theta = 0$, the number of containers handled by both terminals become independent of each other, resulting in a solution at point E3. Here, terminal operators might be tempted to maximise profits by charging monopoly prices. Hence, container terminal operators can leverage on their unique competencies within the six determinants to differentiate their products and services against other competing value-driven supply chain systems. For instance, profitable relationships can be forged along the vertical dimension with supplier and related industries. Although greater differentiation can create opportunities for terminal operators to monopolise their captive markets, it may also invite punitive regulatory actions from governments. Nonetheless, differentiation does also offer the potential for higher market output if the market is contestable (Baumol, Willig and Panzar, 1982).

*Strategy 2: Building Complementary Demand*

Referring to figure 3, building complementary relationships in demand can result in output beyond the solution at E3. Containers handled by two terminals are complementary in demand when a TEU handled by one terminal operator leads to an increase in TEUs handled by another terminal operator. In the case where $-1 < \theta < 0$, the output is represented by the locus of solutions defined by E4. If an increase in TEUs handled by one terminal operator results in an exactly equivalent increase in the TEUs

handled by the other terminal operator, i.e. $\theta = -1$, the solution is denoted by E5. Unlike strategy 1, the impact induced through the existence of complementary demand will simultaneously boost TEUs handled, prices charged and profits earned for each operator.

Hence, terminal operators can make significant gains in terms of TEUs handled by developing complementary relationships. The fact that one port needs another port offers immediate opportunities for container terminal operators to capitalise upon. This argument also lends support to the creation and entrenchment of hub status; whereby any individual terminal operator located within a hub can stand to benefit from multiple pairs of complementary relationships. This strategy should not be confused, however, with the notion of cooperating to build collusive arrangements whereby a monopolistic outcome reduces container throughput to below that of competitive output.

*Strategy 3: Achieve Cost Leadership/ Cost Focus*

Another generic strategy available to container terminal operators is to boost their competitive position by maintaining the same user value compared to competing terminal operators, while achieving lower cost in the provision of the services they offer. The impact of this strategy on equilibrium output can be shown by a fall in costs for $TO_1$ (i.e. a decrease in $c_1$), or a rise in costs for $TO_2$ (an increase in $c_2$). With reference to the competitive scenario ($0 < \theta \leq 1$) shown in figure 4, an increase in costs for $TO_2$ is reflected in the inward shift of RF2 to RF2' while a fall in costs for $TO_1$ is reflected in the outward shift of $RF_1$ to $RF_1'$. The resulting shifts in the reaction functions yield three potential equilibrium solutions; $TO_1$ will stand to benefit most from E4 in terms of TEUs handled and profits earned if it is able to lower its operating cost while $TO_2$ simultaneously suffers from rising costs of operation.

**INSERT FIGURE 4**

The framework presented in figure 2 suggests that the mechanism by which cost leadership can be achieved lies beyond the realm of straightforward changes in simple factor conditions. The dynamics involved in the relationships with related and supporting industries, the role of government and the influence of chance events can all offer alternative avenues for augmenting, or indeed, suppressing a given terminal operator's cost leadership position.

*Strategy 4: Stimulate Greater Demand*

Competition between container terminal operators is likely to intensify when terminals suffer from excess capacity or when the rate of growth in container throughput handled within a shared hinterland slows or declines. However, higher trade volumes, the greater propensity for the containerisation of cargo and a larger level of demand for terminal products and services can help redress this situation. An expansion in the cargo volumes moving along trading corridors that utilise the services of a particular terminal operator can potentially result in higher throughput for that operator. Even though the amount of trade to and from a particular port's hinterland is dependent on the economic health of the region, the terminal operator has an important role to play in the facilitation of this trade. Furthermore, container terminal operators should not neglect the potential to enhance customer value that is offered through the exploitation of other trade determining influences beyond fundamental demand conditions; such as the opportunities provided by collaborating with governments and partners in related and supporting industries.

**INSERT FIGURE 5**

**INSERT FIGURE 6**

An overall expansion in demand, as reflected in a shift to the right in the demand curve for the services offered by terminal operators has the effect illustrated in figure 5 where the number of TEUs handled by $TO_1$ and $TO_2$ rises to $q_1'$ and $q_2'$, respectively, as both reaction functions shift to the right in response to the increase in overall demand. The impact of this strategy is to enable each terminal operator to handle more TEUs, charge higher prices and reap greater profits. Figure 6, in contrast, shows a situation where $TO_2$ cannot respond to the growth in overall demand as it experiences a constraint in terminal capacity at $q_2'$. Hence, $TO_1$ reaps the full benefit of the expansion in overall demand.

*Strategy 5: Reduce the Elasticity of Demand*

From the perspective of the determinants of demand, another strategy that terminal operators can take advantage of is to attempt to influence the elasticity of demand for container terminal services. As can be seen in table 4, Shepherd (1997) summarises the factors affecting the elasticity of demand into those based on: the customer, technical limits, competition and vertical conditions.

**INSERT TABLE 4**

Container terminal operators can work to avoid situations that result in higher price elasticity of demand for the services they offer. Actions that lead to lower demand elasticities include building customer loyalty, creating captive hinterlands, erecting entry barriers and reducing buyer power. The impact of a lower price elasticity of demand

manifests itself in a shift to the right of the reaction functions of both terminal operators as already shown in figure 5. In such a case, both terminal operators can thus handle more TEUs and earn higher profits.

*Strategy 6: Raise Entry Costs*

The increasing complexity of container terminal operation has resulted in the emergence of specialised international container terminal operating companies equipped with the relevant financial, technological and managerial expertise to allow local ports to overcome their various deficiencies. More stringent demands from both landward and seaward port users have meant that terminals now need to address considerations beyond the confines of the terminal itself. Amongst others, these include the efficiency, coverage and accessibility of the hinterland transportation system, logistics and intermodal capabilities, the impact on (or of) terminal operations of (or on) regional economic performance, as well as ecological and environmental issues. These developments can raise entry barriers for the container terminal operating industry.

Shepherd (1997) listed 22 barriers, classified as either exogenous or endogenous, that can deter market entry by raising its costs, feasibility or speed. The presence of entry barriers raises fixed costs, denoted by "F", of the potential entrant. In a situation where there exists a potential new entrant in the form of a third container terminal operator, the cost component for $TO_3$ will be represented by "$c_3 + F_3$" instead of "$c_3$" as in the usual case. With entry, the equilibrium output, price and profit of this operator will be lower vis-à-vis the two incumbents, irrespective of the fact that the incumbents' equilibrium output, price and profit will also decline.

*Strategy 7: Mergers and/or Acquisitions*

Merger and acquisition strategies that result in a lower value of "n" (the number of operators in the market) can be employed to boost commercial power, as well as reap economies of scale and scope. These strategies can also be employed to increase stability and reduce rivalry. Hence, apart from the potential benefit of lower costs, mergers with, or acquisitions of, other terminal operators in the industry can lead to a lower number of TEUs handled, in tandem with higher prices and higher profits if the market has low contestability. However, such a strategy can attract unwanted and punitive regulatory reprisals from governments that are understandably concerned with the welfare losses for society and distributional inequities that increased concentration of the sector may bring about.

*Strategy 8: Acquiring Information Advantage*

Understanding competitors can serve as a means of enhancing a container terminal operator's competitive advantage. Knowledge of markets served, customer profile, productivity, hinterland network, key decision makers, financial strength and employee morale can provide a variety of targets for competitive action. Having access to a greater volume, or higher quality, of information sources than competitors can also offer opportunities to capitalise on first-mover advantages to become, or entrench a position as, the dominant market player. The success of such a strategy, however, is contingent on a container terminal operator's ability to recognise, capture, process and absorb this information and then to take appropriate action on the basis of it.

The impact of information advantage is illustrated by applying Stackelberg's quantity-leadership model (Stackelberg, 1952). Consider a situation where $TO_1$ has information superiority over $TO_2$ and has knowledge of how $TO_2$ will react. Hence, $TO_1$ will factor $TO_2$'s reaction function into its attempts at profit maximisation. Using the model of product differentiation considered in section two, the respective TEUs handled, prices charged and profits for $TO_1$ and $TO_2$ will be:

$$q_1^* = \frac{a(2-\theta) - 2c_1 + c_2\theta}{2b\left(\sqrt{2}-\theta\right)\left(\sqrt{2}+\theta\right)} \quad > \quad q_2^* = \frac{(a-c_2)(2+\theta)(2-\theta) - 2\theta(a-c_1)}{4b\left(\sqrt{2}-\theta\right)\left(\sqrt{2}+\theta\right)}; \tag{12}$$

$$P_1^* = \frac{a(2-\theta) + 2c_1 + c_2\theta}{4} \quad > \quad P_2^* = \frac{(a+c_2)(2-\theta)(2+\theta) - 2\theta(a-c_1) - 2c_2\theta^2}{4\left(\sqrt{2}-\theta\right)\left(\sqrt{2}+\theta\right)}; \tag{13}$$

$$\pi_1^* = \frac{\left[a(2-\theta) - 2c_1 + c_2\theta\right]^2}{8b\left(\sqrt{2}-\theta\right)\left(\sqrt{2}+\theta\right)} \quad \& \quad \pi_2^* = \frac{1}{b}\left[\frac{(a-c_2)(4-\theta^2) - 2\theta(a-c_1)}{4\left(\sqrt{2}-\theta\right)\left(\sqrt{2}+\theta\right)}\right]^2 \tag{14}$$

…where $c_1 = c_2 \Rightarrow \pi_1 > \pi_2$.

The point of solution is shown in figure 7. However, the solution is unstable because it will revert to the Cournot equilibrium if the market leader loses its information advantage. The resulting impact on $TO_1$ will be a reduction in its TEUs handled and its profits. Prices charged by $TO_1$ and $TO_2$ will also increase. Nonetheless, the greater the degree of differentiation the less critical is the impact of information advantage for $TO_1$.

**INSERT FIGURE 7**

*Strategy 9: Pricing Tools*

Pricing strategies that can be used to boost competitive positions in the short run include predatory pricing and price discrimination. $TO_1$ engages in predatory pricing when it

reduces price to below *TO₂*'s average cost in order to drive *TO₂* out of the market, even if it has to suffer losses in the short run to do so. Once *TO₂* exits the market, *TO₁* will raise its price to generate an overall positive economic profit after accounting for the losses incurred during the predation period (Martin, 2002). In this case, $P_1$ is used as a tool for competition where *TO₁* sets $P_1 < c_2$. The impact of this strategy on *TO₁*'s output and profits are indeterminate as it depends on the degree of contestability in the market. In the case of price discrimination, *TO₁* is able to maximise profits through the successful segmentation of a market where there exists no opportunity for its customers to trade between the various market segments. However, these strategies may also trigger negative regulatory responses from governments who are concerned with efficiency losses in the market.

*Strategy 10: Collusion*

Container terminal operators can engage in collusive arrangements to reduce market output and raise prices. Whether tacit or overt, collusion can occur in a variety of horizontal and vertical forms. In this case, the respective output, prices and profits for *TO₁* and *TO₂* become:

$$q_1^* = \frac{a - c_1}{(1+\theta)2b} \quad \& \quad q_2^* = \frac{a - c_2}{(1+\theta)2b}; \tag{15}$$

$$P_1^* = \frac{(a + c_1) + \theta(a + c_2)}{2(1+\theta)} \quad \& \quad P_2^* = \frac{(a + c_2) + \theta(a + c_1)}{2(1+\theta)}; \tag{16}$$

$$\pi_1^* = \frac{(a - c_1)^2(1+\theta) - \theta(a - c_1)(c_1 - c_2)}{4b(1+\theta)^2} \quad \&$$

$$\pi_2^* = \frac{(a - c_2)^2(1+\theta) - \theta(a - c_2)(c_2 - c_1)}{4b(1+\theta)^2} \tag{17}$$

This solution does not satisfy, however, the profit maximisation condition of $MR_{1,2}(q_{1,2})^* = MC_{1,2}(q_{1,2})^*$. In fact, $MR_{1,2}(q_{1,2})^* < MC_{1,2}(q_{1,2})^*$. Hence the solution is unstable, as both container terminal operators have an incentive to cheat on their collusive pact by handling more containers than agreed. Furthermore, the strategy is likely to draw a negative regulatory response from government. Figure 8 shows the locus of potential cartel solutions between points $\frac{a-c_2}{2b}$ and $\frac{a-c_1}{2b}$.

**INSERT FIGURE 8**

This range of possibilities is due to the fact that any specific solution is in part dependent on the respective bargaining power of the two terminal operators. Non-existent or low entry barriers may also render the collusive agreement untenable in the face of potential new entrants to the market.

## 5. Conclusions

For the case of two container terminal operators, table 5 summarises the impact of the ten strategies on the number of TEUs handled, prices charged and profits. The perspective adopted is that of $TO_1$.

**INSERT TABLE 5**

Overall, strategies 2 and 4 are more desirable than the rest because they generate benefits that extend beyond the container terminal operator to the entire industry. Apart from increasing output and profits, these strategies also expand the terminal operator's hinterland. The economies of scale and scope that accrue as a result of an expanded

market could result in even further expansion of output and the generation of even higher profits. From the perspective of the container port cluster, the potential competitive advantages that could be gained by the terminal operator through competition and innovation will cascade throughout the cluster, thereby reinforcing the competitive advantages of other clusters. On the other hand, strategies 6, 9 and 10 could lead to the formation of insular clusters as container terminal operators try to create environments where they face less pressure to seek and interpret new customer needs, technologies and processes.

Monopolistic advantages conferred by restricting market access and/or increasing market concentration could also result in closed and inward-looking systems resulting in cluster degeneration and even disintegration. Hence, while terminal operators try to sustain long-term competitiveness by creating and drawing upon their respective competitive advantages, the most desirable strategies are those that sustain the expansion of, or even revitalise, the market for their services. Furthermore, the framework presented in figure 2 highlights the tremendous amount of opportunities available, in both vertical and horizontal dimensions, for container terminal operators to advance and capitalise on their competitive advantages.

It has been shown that the general framework presented can be used to analyse potential competition strategies and expected payoffs for container terminal operators. While some ports continue to measure their competitiveness based on the ability to attract cargo and shipping tonnage, others realise that the real benefits come from high economic value added and the employment opportunities generated by port and port-related activities.

There are also ports that have come to appreciate the need to balance port development with social and environmental externalities. The framework presented can be used to evaluate competition in the light of these concerns. The framework can also be extended to include demand and cost functions that represent the market conditions for specific locations and to undertake analyses from the perspective of other key players in the container port industry such as shippers, shipping lines, logistics companies and governments.

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**Table 1: Share of Merchandise Trade for Top 10 Trading Nations/Regions in 2000**

| Nation /Region | Total Trade (Billion USD) | Share of World Trade (%) | % Change (1997-2000) |
|---|---|---|---|
| USA | 1,999.29 | 16.10 | 28.42 |
| Germany | 1,041.04 | 8.38 | 9.59 |
| Japan | 802.31 | 6.46 | 11.92 |
| UK | 614.65 | 4.95 | 5.38 |
| France | 589.93 | 4.75 | 8.20 |
| Canada | 531.19 | 4.28 | 26.61 |
| Italy | 471.40 | 3.80 | 6.91 |
| China* | 455.43 | 3.67 | 40.10 |
| Hong Kong* | 414.67 | 3.34 | 4.54 |
| Netherlands | 394.98 | 3.18 | 10.63 |
| **Top 10 Total** | **7,314.89** | **58.91** | **16.27** |

Note: * Includes services.

Source: *World Trade Organisation (2002)*

**Table 2: Share of TEUs* Handled by the Largest Container Terminal Operator in the Top 20 Container Ports in 2000**

| Rank | Port | TEUs Handled | Terminal Operator of Majority Shareholding | Share of Largest Terminal Operator (%) |
|---|---|---|---|---|
| 1 | Hong Kong | 18,100,000 | Hutchison Port Holdings | 42.8 |
| 2 | Singapore | 17,040,000 | PSA Corporation | 99.7 |
| 3 | Pusan | 7,540,387 | Hutchison Port Holdings | 24.5 |
| 4 | Kaohsiung | 7,425,832 | n.a. | n.a. |
| 5 | Rotterdam | 6,275,000 | Europe Combined Terminals | 70.1 |
| 6 | Shanghai | 5,613,000 | Hutchison Port Holdings | 51.7 |
| 7 | Los Angeles | 4,879,429 | n.a. | n.a. |
| 8 | Long Beach | 4,600,787 | n.a. | n.a. |
| 9 | Hamburg | 4,248,247 | HHLA | 50.6 |
| 10 | Antwerp | 4,082,334 | Hessenatie | 60.0 |
| 11 | Shenzhen | 3,993,714 | Hutchison Port Holdings | 53.8 |
| 12 | Port Klang | 3,206,753 | Northport | 89.8 |
| 13 | Dubai | 3,058,886 | Dubai Ports Authority | 100.0 |
| 14 | New York/ New Jersey | 3,006,493 | n.a. | n.a. |
| 15 | Tokyo | 2,899,452 | Nippon Container Terminals | 16.8 |
| 16 | Manila | 2,867,836 | ICTSI | 41.5 |
| 17 | Felixstowe | 2,800,000 | Hutchison Port Holdings | 100.0 |
| 18 | Bremen/ Bremerhaven | 2,712,420 | Eurogate | 57.4 |
| 19 | Gioia Tauro | 2,652,701 | Contship Italia | 100.0 |
| 20 | Tanjung Priok | 2,476,152 | Hutchison Port Holdings | 68.7 |
| | **Total** | **109,479,423** | **47.3% of 231.7 million TEUs handled in the world** | |

*Twenty-foot Equivalent Unit; a standard size of container as recognised by the International Standards Organisation (ISO).

Source: *Containerisation International Yearbook (2003) and various port websites.*

**Table 3: Schematic of Porter's "Diamond" Model Applied to the Container Terminal Industry**

| Determinant | Components | Important for Container Terminal Operators to Create and Sustain Competitive Advantage |
|---|---|---|
| Factor conditions | Factor Endowment<br>Factor Hierarchy | - Availability of skilled, specialised, competent and motivated human resources<br>- Favourable maritime access<br>- Strategic geographic location<br>- Stable climate<br>- Available and abundant stock of scientific, technical and market knowledge<br>- Available and accessible sources of financial capital<br>- A high quality port infrastructure<br>- Good transportation network to access hinterland<br>- Modern communications infrastructure<br>- Active participation in factor-creation<br>- Advanced and specialised factors most crucial |
| Demand conditions (e.g. of local hinterland) | Demand Composition<br>Demand Size and Growth Pattern<br>Demand Internationalisation | - Quality of demand important for perceiving, interpreting and responding to user needs<br>- The segment structure of demand shapes the attention and priorities of terminal operator<br>- Sophisticated and demanding users provide window to future user needs<br>- Size of demand important especially for cases involving substantial R&D, scale economies, uncertainty and technological requirements<br>- Presence of a number of independent users foster faster rate of innovation<br>- Rapid demand growth encourages investment in new products and facilities<br>- Early saturation of demand increases pressure to innovate and upgrade<br>- Mobile or multinational local users can provide loyal customer base<br>- Inculcate domestic user needs into foreign users to internationalise demand base |
| Related and supporting industries | Supplier industries<br>Related industries | - Presence of internationally competitive supplier industries<br>- Presence of internationally competitive related industries |
| Firm strategy, structure and rivalry | Strategy and structure of firm<br>Goals<br>Domestic rivalry<br>New business formation | - Management practices and mode of organisation must concur with national circumstances<br>- Succeed when goals and motivation stimulate unusual commitment and effort<br>- Status of national priority and/or prestige attracts outstanding talent and resources<br>- Importance of sustained commitment<br>- Successful operators compete intensely for home market and pressure each other to improve and innovate<br>- New business formation feeds the process of innovation |
| Chance | Events beyond ability of firm and government to influence | - Capitalise on opportunities created from discontinuities that shift competitive advantage |
| Role of government | National, regional and local | - Potential impact from government policies<br>- Opportunity to work together with government to reinforce competitive advantage |

**Table 4: Factors Influencing Elasticity of Demand**

| Category | Factors | Impact of Demand Elasticity |
|---|---|---|
| Customer | Stronger preferences (e.g. habits)<br>Higher income<br>Greater wealth<br>Knowledge | Less elastic<br>Less elastic<br>Less elastic<br>More elastic |
| Technical limits | Poor physical connections and apparatus | Less elastic |
| Competition | Intense and extensive competition<br>Threat of entry | More elastic<br>More elastic |
| Vertical conditions | Monopsony power<br>Ability to self-supply | More elastic<br>More elastic |

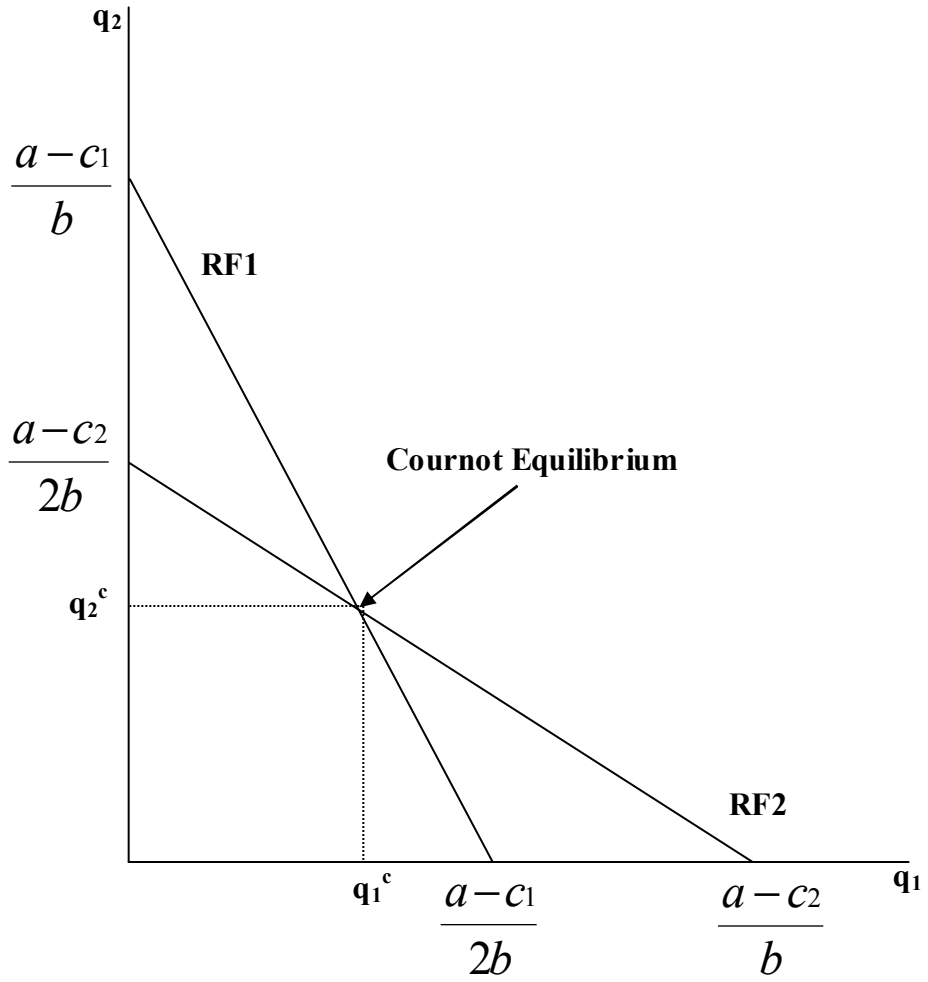
Source: *Shepherd (1997)*

**Table 5: Summary of Impact of $TO_1$'s Competitive Actions (for $0 < \theta \leq 1$)**

| No. | Strategy | $Q_1$ | $Q_2$ | $P_1$ | $P_2$ | $\pi_1$ | $\pi_2$ |
|---|---|---|---|---|---|---|---|
| 1. | Differentiate Demand | | | | | | |
| | (i) If high contestability | ↑ | ↑ | ↓ | ↓ | ↓ | ↓ |
| | (ii) If low contestability | ↓ | ↓ | ↑ | ↑ | ↑ | ↑ |
| 2. | Build Complementary Relationship | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 3. | Cost Leadership/ Cost Focus | | | | | | |
| | (i) $\downarrow c_1$ | ↑ | ↓ | ↑ | ↓ | ↑ | ↓ |
| | (ii) $\uparrow c_2$ | ↑ | ↓ | ↑ | ↓ | ↑ | ↑ |
| | (iii) $\downarrow c_1$ and $\uparrow c_2$ | ↑ | ↓ | ↓* | ↑* | ↑ | ↓ |
| 4. | Stimulate Greater Demand | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 5. | Reduce Demand Elasticity | ↑ | ↑ | - | - | ↑ | ↑ |
| 6. | Raise Entry Costs (with entry) | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 7. | Mergers and/or Acquisitions | | | | | | |
| | (i) If high contestability | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| | (ii) If low contestability | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 8. | Acquiring Information Advantage** | ↑ | ↓ | ↓ | ↓ | ↑ | ↓ |
| 9. | Pricing Tools | | | | | | |
| | (i) With $TO_2$ in the market | ↑ | ↓ | ↓ | ↓ | ↓ | ↓ |
| | (ii) With $TO_2$ leaving the market | ↓ | - | ↑ | - | ↑ | - |
| 10. | Collusion | ↓ | ↓ | ↑ | ↑ | ↑ | ↑ |

Notes * For $0 < \theta < 1$. If $\theta = 1$, there will be no change to $P_1$ and $P_2$.
** For $\theta = 1$.

**Figure 1: Cournot's Equilibrium with Product Differentiation where θ = 1**




| Decision Variables | | Endogenous Variables |
|---|---|---|
| a | | $P_i$ |
| b | | $q_i$ |
| $c_i$ | → | $\pi_i$ |
| θ | | |
| n | | |
| $F_i$ | | |

where i denotes TOi

**Figure 2: Framework for Analysing Competition Between Container Terminal Operators**

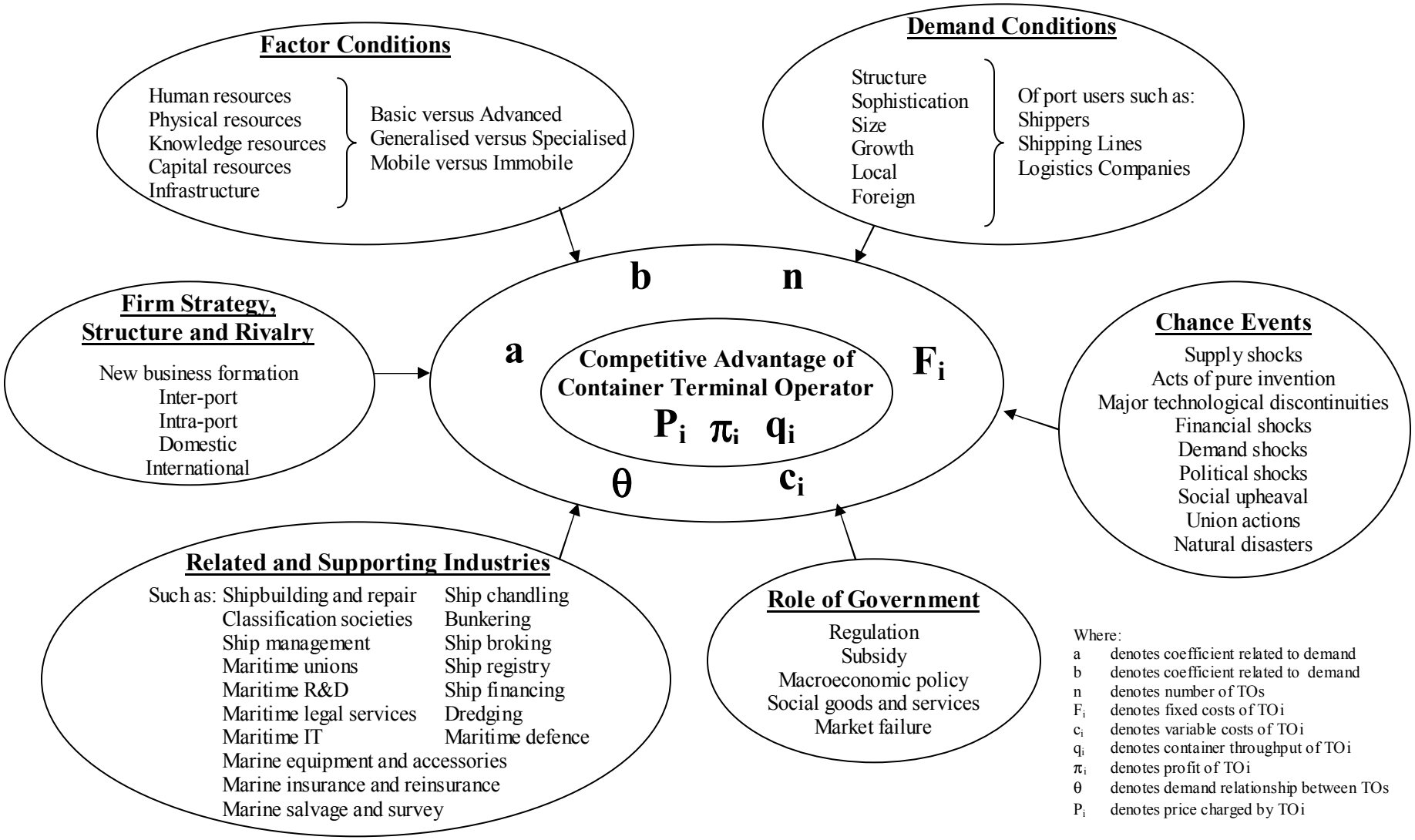


**Figure 3: Solutions for the Case of Product Differentiation for two Container Terminal Operators**

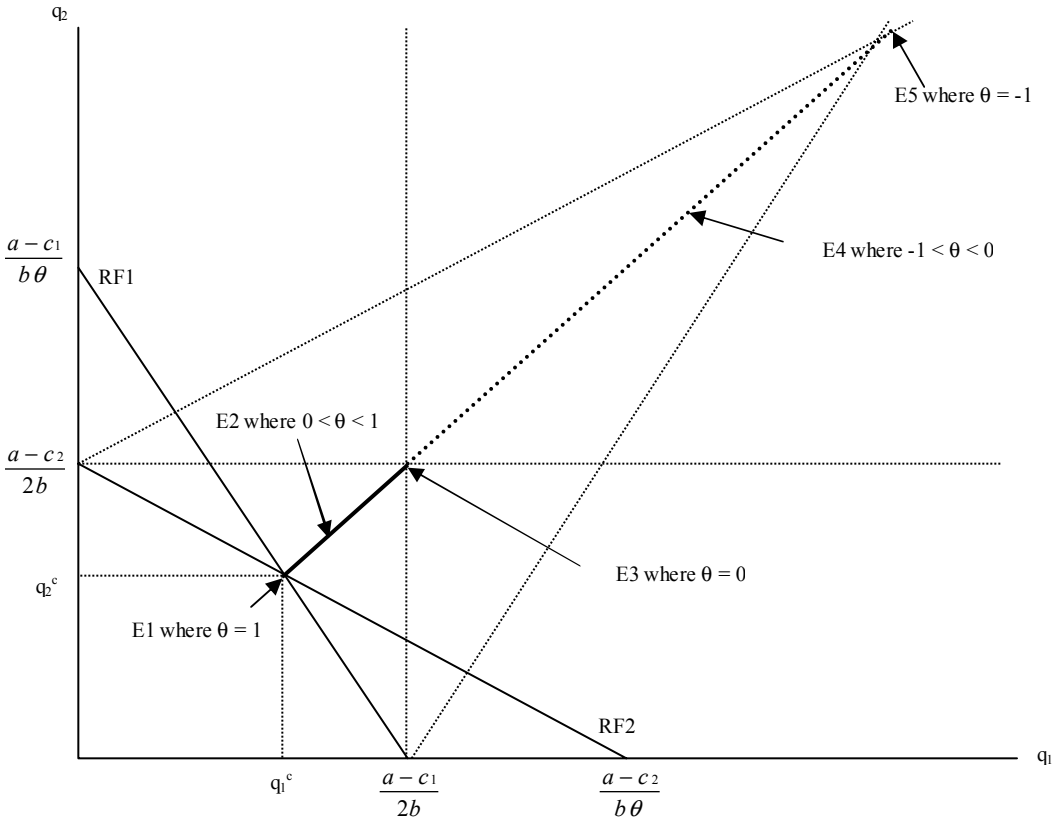
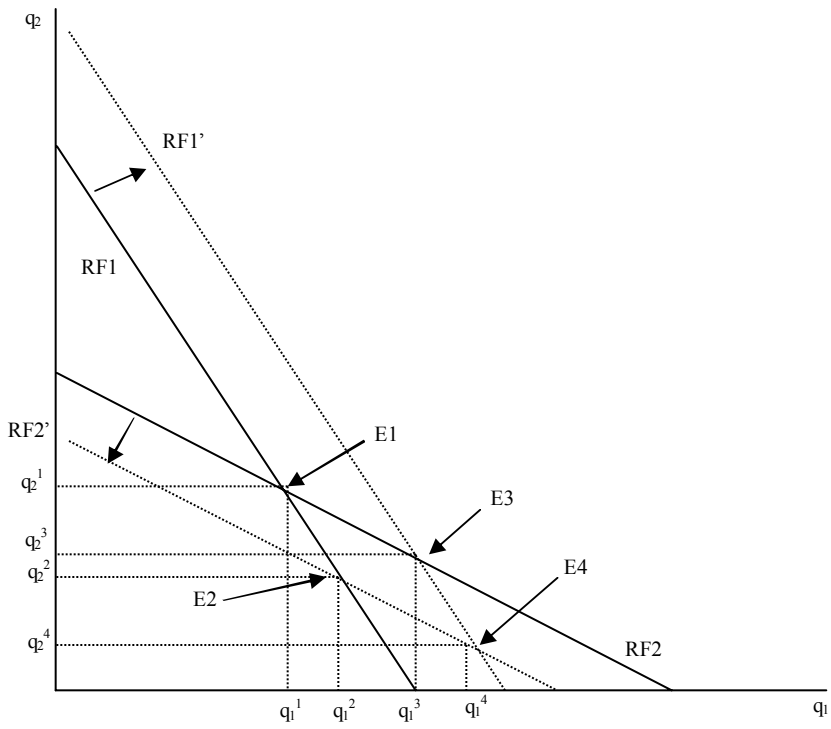


**Figure 4: Achieving Cost Leadership/ Cost Focus in the Case of Two Competing Container Terminal Operators where θ =1**




Where:

E1 denotes the original equilibrium position in Cournot's model
E2 denotes the equilibrium position resulting from a rise in $TO_2$'s costs. Hence, $\downarrow q_2$ and $\uparrow q_1$
E3 denotes the equilibrium position resulting from a fall in $TO_1$'s costs. Hence, $\downarrow q_2$ and $\uparrow q_1$
E4 denotes the equilibrium resulting from a rise in $TO_2$'s costs and fall in $TO_1$'s costs. Hence, $\downarrow q_2$ and $\uparrow q_1$ (The best situation for $TO_1$ and worst situation for $TO_2$).

**Figure 5: Equilibrium with Expansion in Demand where θ = 1**

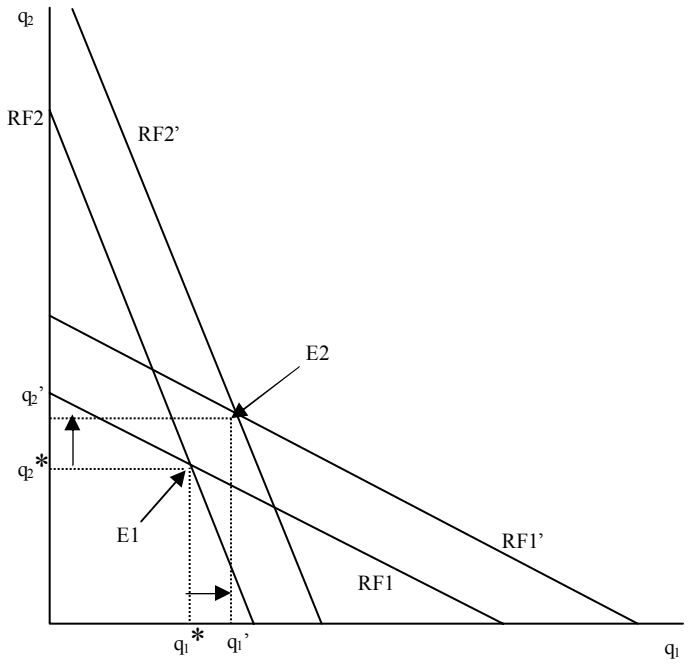


**Figure 6: Equilibrium with Demand Expansion and Capacity Constraint for *$TO_2$* at q2' where θ = 1**

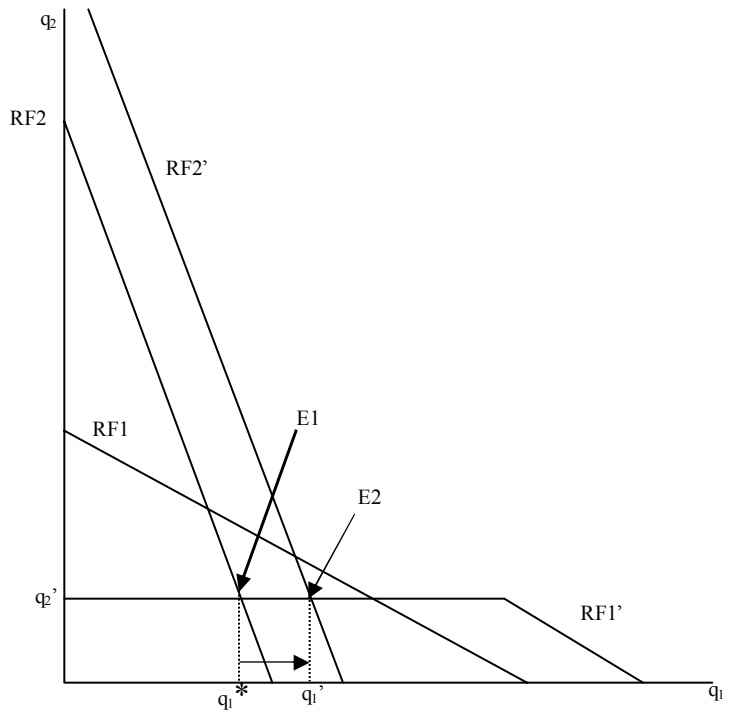


**Figure 7: The Stackelberg Solution for the Case of θ = 1**

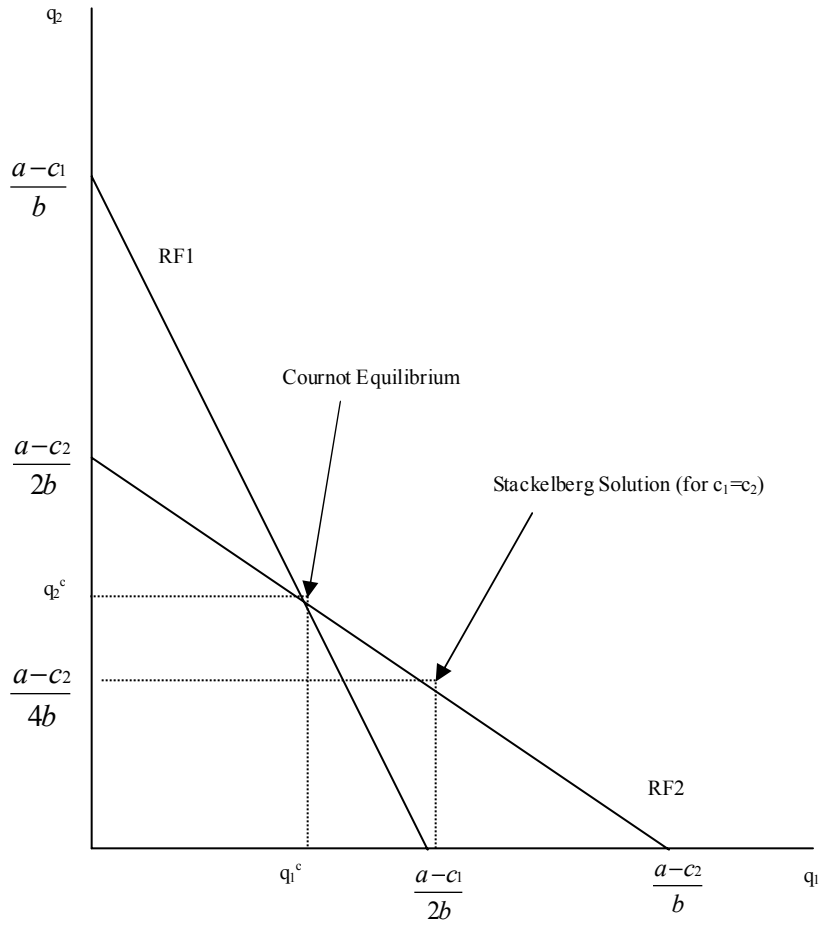


**Figure 8: Cartel Solutions for the Case of θ = 1**