1. Introduction

The important role of aquaculture in food supply and economic growth has been well recognized (FAO, 2000; 2002; 2004; 2006). While aquaculture accounted for only 3.5 percent of the supply of aquatic products in the world during the early 1950s, the ratio had risen to 10 percent by the early 1980s, 35 percent by the early 2000s (FAO, 2004) and about 42 percent by 2006 (FAO, 2006). Increasing seafood demands driven by income and population growth under a situation of limited and depleting fisheries resources require aquaculture to play an even more important role in the future (FAO, 2006).

Fortunately, aquaculture is still a new and underdeveloped industry with great potential in many regions such as Africa (Kapetsky, 1994; Aguilar-Manjarrez and Nath, 1998) and Latin America (Kapetsky and Nath, 1997). Yet experience (especially in Africa) has shown that it is far from easy to realize these potentials (Machena and Moehl, 2001).

Successful aquaculture development depends on many factors; getting started on the right track is one of them. A special feature of aquaculture is that there are many species to choose from.[1] Even for the same species, there may be many markets to target. While skilled aquaculturists can make decisions based on their experience and visions, many entrepreneurs in aquaculture may need guidance to pick systems that could give them the greatest chances for long-run success. Similarly, in providing public support to aquaculture development, international funding agencies and local governments face the problem of "picking the winners". That is, they have to prioritize and allocate limited resources and aid to aquaculture activities with the most likelihood of achieving sustainable success. Thus, information on a country's "comparative advantage" in different aquaculture activities is important for both commercial and policy decision-making processes.

The objective of this study is to develop a basic, yet systematic framework for assessing countries' comparative advantages in competing aquaculture activities, discuss how this framework can help entrepreneurial and policy decision-making in aquaculture development, and illustrate the practical application of the framework.

This report is organized in five sections. Following these introductory remarks, Section 2 discusses two approaches commonly used in the economics literature for assessing comparative advantage. One is the domestic resource cost (DRC) or benefits-costs (BC) approach; the other is the revealed comparative advantage (RCA) approach. A discussion on the respective merits and limitations of each of these two complementary approaches and on how the two methods can be used to guide policy is provided at the end of this section.

Sections 3 and 4 illustrate two empirical applications of the assessment framework developed in section 2, with a focus on the RCA approach. Because of a lack of data on aquaculture production costs, the report does not illustrate the application of the DRC method, which is nevertheless well established and documented in the literature. More specifically, Section 3 evaluates the comparative advantage of major shrimp farming countries in exporting frozen cultured shrimp to three major international markets (Japan, the United States of America and the European Union). In section 4, the revealed comparative advantage in the production of three freshwater finfish

[1] Production data for 103 fish species, 21 crustacean species and 43 mollusc species were reported to FAO in 1994 (FAO, 1996).

species (tilapia, catfish, and carp) by countries in three regions (Asia, Latin America and the Caribbean and sub-Saharan Africa) is assessed. A comparative advantage study of shrimp farming in these three regions will also be conducted when data become available.

Section 5 summarizes the major findings of the study and the most relevant implications for entrepreneurs and policy-makers.

2. Comparative advantage in aquaculture: an assessment framework

2.1 CONCEPT OF COMPARATIVE ADVANTAGE

The concept of comparative advantage was first expressed by Robert Torrens in 1815 in his paper titled *Essay on the external corn trade*. However, the theory is usually attributed to David Ricardo who created its systematic explanation in his book on *"Principles of political economy and taxation"* in 1817. Using a two-nations (Portugal and England) and two-commodities (wine and cloth) model, Ricardo argued that trade would be beneficial even if Portugal held an *absolute* cost advantage over England in both commodities (Suranovic, 2008). Hence, Ricardo provided insight that free trade allows countries to gain from increasing specialization in activities in which they have (strong) comparative advantage under autarky.

More generally, comparative advantage is a concept commonly used to explain specialization and trade patterns. It refers to an entity (country, region, company, individual)'s ability to produce a good or service at a lower cost, relative to other goods or services, compared to another entity. In economic jargon, an entity has a comparative advantage over another in the production of a good or service if it can produce it at a lower opportunity cost, meaning that it has to give up less labour and other productive resources that could be used in the production of other goods or services, in order to produce it (Thompson, 2006).

The concept of comparative advantage has two aspects: normative and positive. Normatively, it is in an entity's interest to highly specialize (as compared to other countries) in the production of goods or services in which it has a strong comparative advantage. Positively, under perfect competition and undistorted markets, an entity has a tendency to highly specialize in and export goods or services in which it has a strong comparative advantage while it imports those goods in which it has a weak comparative advantage.

Comparative advantage can be analysed from two different perspectives: static and dynamic. In a static sense (the Ricardian sense), comparative advantage is a concept used to compare entities' current optimal specialization and trade patterns. Thus, by stating that country A has a strong comparative advantage in tilapia farming, it is implied that the country's current optimal specialization level (that is, the specialization level that reflects efficient resource allocation) in tilapia farming is higher than those of other countries. In a dynamic sense, the concept is used to compare entities' future optimal specialization and trade patterns by recognizing that an entity's relative ability to competitively produce certain goods and services can be eroded or enhanced with time, in response to a variety of endogenous and exogenous factors such as changes in factor endowments and their opportunity costs (physical capital, human capital/labor, land), changes in production and marketing technologies and changes in world input and output prices.

It is very important to distinguish these two dimensions of comparative advantage because they have different policy implications. For example, stating that country A has a strong comparative advantage in tilapia farming in the *static* sense implies that the activity is important for the country but does not necessarily imply that it should

be promoted any further. If the country's actual specialization level in tilapia farming is already optimal, then an attempt to further increase the specialization could be counterproductive. However, stating that a country has a strong comparative advantage in tilapia farming in the *dynamic* sense implies that the country should have a tendency to increase its specialization in tilapia farming.

Regarding general statements such as "country A has a comparative advantage in activity X", two other factors need to be clarified. First, when making such statements, it is important to clarify *what other activities* is country A's "comparative" advantage in activity X relative to. For example, country A's comparative advantage in tilapia farming may reflect its low *opportunity costs* in engaging in this activity relative to carp farming. If resources that could have been used for farming carps were used to farm tilapia, then the advantage is comparative to country A's carp farming activities as carp farming competes with tilapia farming for resources. Second, it is important to clarify *what other countries* is country A's comparative advantage compared to. In this context, country A's strong comparative advantage in tilapia farming implies that the country tends to have a higher specialization in the activity as compared to other countries. These "other countries" could include all the countries in the world, countries in the region where country A is located, or a group of countries specifically chosen for comparison.

An additional point deserves clarification. Comparative advantage is often confused with absolute advantage. Absolute advantage refers to an entity's ability to produce a good or service at a lower cost per unit than the cost at which any other entity produces that good or service. Under absolute advantage, one entity can produce more output of a good or service per unit of productive input as compared to other entity, but lack comparative advantage (the determinant of specialization and trade) in the same good or service produced.

With comparative advantage, even if one producing entity has an absolute (dis) advantage in every type of output, it can benefit from specializing in and exporting those products in which it has a relative advantage (that is, a lower opportunity cost) and importing the goods in which it has a relative disadvantage (higher opportunity cost). What matters is not the absolute cost of production but the relative opportunity cost, which measures how much production of one good or service is reduced to produce one more unit of the other good or service.

In sum, the concept of comparative advantage has two useful applications. First, it serves as a descriptive (or "positive") concept that provides "a basic explanation of the international pattern of specialization in production and trade". Second, it "plays an important role in prescriptive (or "normative") economics" by "providing guidelines for government policies on resource allocation and trade" (UNIDO, 1986).

2.2 COMPARATIVE ADVANTAGE VERSUS COMPETITIVE ADVANTAGE

Similar to "comparative" advantage, another widely used term is "competitive" advantage. While these two terms are oftentimes used indistinguishably and interchangeably, they are sometimes used in parallel for denoting different concepts.

According to one distinction that is not well established in the literature, yet it is popular in empirical studies (Warr, 1994; Odhiambo, Kristjanson and Kashangaki, 1996; Hassan *et al.*, 1999; Jooste and van Zyl, 1999; Kannapiran and Fleming, 1999; Magagula and Faki, 1999; Nakhumwa *et al.*, 1999; Saasa *et al.*, 1999; USAID, 1999; Mucavele, 2000; Sukume *et al.*, 2000; Siggel and Ssemogerere, 2004), competitive advantage measures a country's (or other entities') profitability in one activity under "market" prices that could be distorted by policy or any other influence, while comparative advantage reflects the profitability under "shadow" prices that reflect the social value of costs and production subject to no such distortions.

This study does not follow this distinction because it does not reflect the spirit of "comparative" advantage. In our view, the distinction between competitive advantage and comparative advantage is similar to that between "absolute" and "comparative" advantage. For example, while Thailand's large cultured shrimp production offers a strong "competitive" advantage in all its cultured shrimp export markets, the degree of the advantage tends to be different for each market. The concept of "comparative advantage" is to capture such differences. Thus, if Thailand's *competitive* advantage in the United States market is greater than the advantage of its total exports to other world markets, then one can say that Thailand has a *comparative* advantage in the United States market relative to other markets.

In sum, comparative advantage is a concept intended to compare countries' industrial structures rather than comparing the competitiveness of their industries directly. In other words, comparative advantage reflects "efficient allocation of resources at the national level" as opposed to "the commercial performance of individual firms" reflected by competitive advantage (Kannapiran and Fleming, 1999).

2.3 COMPARATIVE ADVANTAGE: AN ASSESSMENT FRAMEWORK

The economics literature provides two complementary approaches for comparative advantage assessment. One is the domestic resource cost (DRC) or the equivalent "benefit-cost" (BC) approach (Odhiambo, Kristjanson and Kashangaki, 1996; Hassan *et al.*, 1999; Jooste and van Zyl, 1999; Magagula and Faki, 1999; Nakhumwa *et al.*, 1999; Saasa *et al.*, 1999; USAID, 1999; Mucavele, 2000; Sukume *et al.*, 2000); the other is the "revealed comparative advantage" (RCA) approach (Balassa, 1965; Vollrath, 1991; Memedovic, 1994).

The following first introduces how these two approaches in comparative advantage assessment have been employed in the literature and then are synthesized into a general framework.

2.3.1 The domestic resource cost/benefit-cost approach

The spirit of the DRC/BC approach is to measure a country's comparative advantage in an activity by its social profitability from engaging in the activity.

Benefit-cost analysis

The benefit-cost (BC) analysis directly measures the profitability of an economic activity by the following formula:

$$BC_{ij} = p_{ij} \Big/ c_{ij}, \tag{1}$$

where p_{ij} and c_{ij} represent the (average unit) price and cost of country i's production of good j, respectively.

Suppose $BC_{ij} > 1$, which according to equation (2.1) implies country *i's* production of good j is profitable (i.e. the revenue p_{ij} is greater than the cost c_{ij}); then this country is deemed as having "comparative advantage" in producing good j. The larger the BC ratio becomes, the greater the advantage is. In contrast, $BC_{ij} < 1$, which indicates that country *i's* production of good j is not profitable, would imply that this country has "comparative disadvantage" in producing good j. The smaller the BC ratio is, the greater the disadvantage would be.

DRC analysis

Domestic resource cost (DRC) analysis measures a country's efficiency in domestic resource utilization in the production of certain goods by means of the following formula:

$$DRC_{ij} = \frac{c_{ij}^{d}}{p_{ij} - c_{ij}^{f}} \quad , \tag{2}$$

where c_{ij}^{d} and c_{ij}^{f} represent respectively domestic and foreign input costs for country *i*'s production of good *j* – note that $c_{ij} = c_{ij}^{d} + c_{ij}^{f}$ (*i.e.* the total input cost is equal to the sum of domestic and foreign input costs).

A DRC ratio of less than one (i.e. $DRC_{ij} < 1$) implies that country *i* uses domestic resources efficiently in the sense that the domestic opportunity cost of country *i's* production of good *j* (measured by c_{ij}^{d}) is less than the domestic value-added generated by the production process (measured by $p_{ij} - c_{ij}^{f}$). In contrast, $DRC_{ij} > 1$ implies an inefficient use of domestic resources.

Therefore, $DRC_{ij} < 1$ is an indication that country *i* has a "comparative (economic) advantage" in producing good *j*. The smaller the DRC_{ij} is, the greater the advantage would be. Conversely, $DRC_{ij} > 1$ indicates the existence of country *i's* "comparative (economic) disadvantage" in producing good *j*. The larger the DRC_{ij} is, the greater the disadvantage would be.

Since $c_{ij} = c_{ij}^{d} + c_{ij}^{f}$, equations (1) and (2) imply that $DRC_{ij} < 1$ and $BC_{ij} > 1$ are equivalent. Therefore, the BC and DRC approaches are essentially the same.

Shadow prices

One key feature of the DRC/BC approach is to use "shadow prices" to value production revenues and costs. As opposed to observable market prices, shadow prices are "social" prices that take into account market distortions. For example, a country's low aquaculture production costs may not be a result of its high efficiency or productivity, but because of direct or indirect government subsidies in energy, feeds, water, or other production factors. Therefore, the use of distorted market prices to measure profitability tends to result in a "false" indication of comparative advantage or disadvantage.

To avoid such misrepresentation, shadow prices, which purge market prices from policy and other distortions and hence provide a measure of the true or social value of production costs and revenues, should be used to calculate the DRC/BC ratios for comparative advantage measurement.

Policy analysis matrix

Empirically, the policy analysis matrix (PAM) is a convenient tool for the DRC/BC analysis (Monke and Pearson, 1989). Table 1 shows a standard PAM, based on which at least four indicators of comparative advantage can be derived:[2]

(1) Net private profit: NPP = A – B – (C + D)
(2) Net social profit: NSP = (E – F) – (G + H)
(3) DRC^{market} = (C + D) / (A – B)
(4) DRC^{shadow} = (G + H) / (E – F)

Indicators (1) NPP and (2) NSP, which are based on the BC method, measure industries' profitability under market and shadow prices, respectively. A high NPP means a large profit margin and hence great competitiveness. However, as discussed above, a high NPP could be artificially created by subsidies, protection, tax breaks or other policy distortions and hence may not be sustainable in the long run. Therefore, the NSP (calculated at shadow prices) would reflect the "true" competitiveness of an industry.

Indicators (3) DRC^{market} and (4) DRC^{shadow}, which are based on the DRC approach, measure the relative efficiency of the use of domestic resources by an industry. The

[2] Table 1 is adopted from Nakhumwa *et al.* (1999), who discussed additional indicators that can be constructed based on PAM.

TABLE 1
Policy analysis matrix (PAM)

	Revenues	Tradable input costs	Capital/ labour cost	Land cost	Profits
Private prices	A	B	C	D	NPP
Social (shadow) prices	E	F	G	H	NSP
Policy effects (or transfers)	K	L	M	N	O

lower the DRC ratio is for an industry, the smaller amount of domestic resources the industry needs to use in order to generate a given amount of net foreign exchange revenue; hence, the more efficient the industry is in utilizing domestic resources.

The difference between DRC^{market} and DRC^{shadow} is similar to that between NPP and NSP in the use of market vs. shadow prices.

2.3.2 The RCA approach

The spirit of the "revealed" comparative advantage (RCA) approach is to use *ex post* specialization patterns to infer comparative advantage patterns: a country's actual high specialization in an activity can be viewed as an evidential indication that it has strong comparative advantage in that activity (Balassa, 1965). Comparative advantage is "revealed" (as opposed to actual) in that rather than reflecting a country's true comparative advantage, high specialization could be a result of policy interventions.

Based on this basic methodology, many different RCA indices have been suggested and disputed – see Appendix A for a review. While a consensus is yet to be reached, the standard Balassa's RCA measure (Balassa, 1965) is the most widely used by applied economists and will be adopted in this study.

RCA index defined in terms of relative competitiveness

Let X_{ij} denote individual country i's export of product j; then the standard Balassa's RCA index can be defined as

$$RCA_{ij} = \frac{s_{ij}}{s_i}, \tag{3}$$

where

$s_{ij} = \dfrac{X_{ij}}{\sum_i X_{ij}}$ denotes country i's share in export market j, and

$s_i = \dfrac{\sum_j X_{ij}}{\sum_i \sum_j X_{ij}}$ denotes the share of country i's total exports in the entire world export market.

Therefore, according to equation (3), RCA_{ij} essentially compares country i's share in export market j to its share in the entire world export market. In other words, RCA_{ij} measures country i's comparative advantage in product j by comparing its competitiveness in market j (measured by its share in the market) to the competitiveness of its total exports (measured by its share in the entire world market).[3]

Therefore, $RCA_{ij} > 1$, which indicates that country i's share in market j is greater than its share in the world market, implies that the country is relatively more competitive

[3] A "constant market share" (CMS) condition has often been used to evaluate countries' export competitiveness (e.g. Bowen and Pelzman, 1984; Chen, Xu and Duan, 2000; Richardson, 1971a; 1971b). A country that can keep its market share constant is deemed as being able to maintain its "competitiveness" in the market.

in market *j* than in other markets. This is often taken as evidence that country *i* has a "revealed comparative advantage" in exporting product *j*. Conversely, $RCA_{ij} < 1$ implies that country *i* is less competitive in market *j* than in other markets, which is often taken as evidence that country *i* has a "revealed comparative disadvantage" in exporting product *j*.

RCA index defined in terms of relative specialization

Equivalent to equation (3), the RCA index can also be defined in another form as

$$RCA_{ij} = \frac{c_{ij}}{c_j}, \tag{4}$$

where

$c_{ij} = \dfrac{X_{ij}}{\sum_j X_{ij}}$ represents the proportion of country *i*'s export of product *j* to its total exports; and

$c_j = \dfrac{\sum_i X_{ij}}{\sum_i \sum_j X_{ij}}$ represents the proportion of total world exports of product *j* relative to the total world exports of all products.

According to equation (4), $RCA_{ij} > 1$ implies that country *i*'s export specialization in product *j* (measured by c_{ij}) is higher than the world average export specialization in the product (measured by c_j), which provides another interpretation of country *i*'s comparative advantage in product *j*.

Conversely, $RCA_{ij} < 1$ implies that country *i* has below-average export specialization in product *j*, which indicates its comparative disadvantage in that product.

Flexibility in the application of the RCA approach

In essence, the RCA approach uses specialization patterns to infer comparative advantage patterns. Based on this premise, many RCA indices can be constructed to compare countries' specialization patterns in many activities (Richardson and Zhang, 1999). For example, an RCA index can be constructed to compare countries' comparative advantage patterns in exporting one aquaculture product (e.g. shrimp) to different markets; another RCA index can also be calculated to compare countries' comparative advantage patterns in producing different cultured species (e.g. tilapia, catfish and carp). Furthermore, at a more disaggregated level, an RCA index can be calculated to measure countries' comparative advantage in exporting different kinds of products for a single species (Ling, Leung and Shang, 1996).

Revealed comparative advantage variation (RCAV)

While RCA indices defined in equation (3) or (4) provide a snapshot of countries' comparative advantage patterns at a certain point of time, it is also informative to know how such patterns vary over time. Comparative advantage variation over time is often directly measured by the changes in RCA indices (e.g. Yeats, 1992; Hiley, 1999; Bojnec, 2001; Havrila and Gunawardana, 2003). That is, a higher RCA_{ij} index at time $t+1$ than at time *t* implies that country *i* has increased its comparative advantage in product *j*, while a lower RCA_{ij} index implies the opposite.

While the RCA literature seems to take this method for granted, we are aware of no attempt to theoretically justify it. However, the method is actually problematic. In Appendix B we show that a more appropriate indicator (with theoretical foundation) that measures revealed comparative advantage variation (RCAV) is

$$RCAV_{ij} = RCA_{ij,t+1} - \beta RCA_{ij,t}, \quad (5)$$

where $$\beta \equiv \frac{1+g}{1+\sum_j c_{ij,t} g_j},$$

g_j represents the growth rate of total world exports of product j, and
g represents the growth rate of total world exports of all products.

Since $\sum_j c_{j,t} g_j = g$,

β would be unity when $c_{ij,t}$ is identical to $c_{j,t}$ for every product j, which, according to equation (4), implies that $RCA_{ij,t} = 1$ for every product j. Therefore, for a country whose specialization pattern is similar to the world average, β would be close to unity; hence the direct use of the variation of the RCA index would not matter much. However, for a country whose specialization pattern is quite different from the world average, β can be substantially different from unity; hence the direct use of the RCA index in gauging its variation could lead to misleading conclusions.[4]

2.4 COMPARATIVE ADVANTAGE ASSESSMENT: A SYNTHESIS FRAMEWORK

Comparative advantage is a concept for explaining countries' (or other entities') specialization patterns. DRC/BC and RCA are two common approaches for comparative advantage assessment. They are complementary and have respective merits and problems. Their proper application can provide useful information for commercial and policy guidance.

2.4.1 The DRC/BC approach: merits and problems

The DRC/BC approach uses a country's shadow-price profitability in an economic activity to measure its comparative advantage in that activity. High profitability implies strong advantage. It should be noted that comparative advantage measured by this approach is in the dynamic sense. For example, suppose a country's DRC ratio for tilapia farming is lower than that for other freshwater species farming, which implies that the country can use resources more efficiently in tilapia farming and hence has strong comparative advantage in it. Then, the country should increase specialization in tilapia; in other words, tilapia should be a priority in its aquaculture development.

This direct policy implication is the main appeal of the DRC/BC approach. However, a methodological problem needs to be cautioned. In calculating DRC/BC ratios, shadow prices are used to value the social costs of production in order to avoid the influence of market distortions. The problem is that actual input structures adopted by producers react to such distortions. For example, suppose feed prices are artificially kept at a distorted low level; farmers would then tend to adopt more feed-intensive production systems. Thus, when feeds are valued under their shadow prices, those species that react to the artificial low feed prices more significantly would tend to appear more socially inefficient and hence be more likely to be deemed as having relatively weak comparative advantage, even though they could actually be socially efficient were farmers' behaviours not affected by the distorted feed prices in the first place.

Another problem of the DRC/BC approach is that short-term, dynamic comparative advantage indicated by a low DRC ratio is not necessarily consistent with comparative advantage in the long run. For example, suppose a country begins tilapia farming

[4] See Appendix B for an example of such misleading conclusions.

earlier than its potential competitors and DRC ratios indicate that it has a strong comparative advantage in it. While this advantage could reflect the country's inherent characteristics that allow it to culture tilapia relatively more efficiently, it could also be transitory and disappear when tilapia farming becomes more popular elsewhere. This could occur from a decline in tilapia price due to supply increases by other countries, a rise in tilapia production costs induced by production expansion, or both. Therefore, by neglecting the dynamic nature of comparative advantage, the country could over-commit to tilapia and result in an industrial structure that is actually at odds with its long-term comparative advantage pattern.

Empirically, one difficulty in applying the DRC/BC approach is the lack of quality data on production costs.

2.4.2 The RCA approach: problems and merits

The spirit of the RCA approach is to infer countries' comparative advantages in different activities by systematically comparing their specialization patterns in these activities. For example, the evidence that a country consistently has a relatively high specialization level in one species as compared to other countries indicates that the country may have some special characteristics in natural resource endowment structure, climate, local tastes, technology, human capital, etc., that give it a comparative advantage in that activity. However, a well-recognized problem is that strong "revealed" comparative advantage indicated by high RCA indices may not be a country's "true" comparative advantage, but could be artificially created by policy or other distortions.

From a policy-making perspective, another shortcoming of the RCA approach is that it does not provide direct policy recommendations. For example, suppose a country has a high RCA index for tilapia farming, which indicates that it has relatively high specialization (i.e. strong comparative advantage) in that activity. Although this indicates that tilapia farming is important for the country, it is not clear whether the relatively high specialization level is already optimal: should the government further promote the industry, maintain the status quo, or even reduce the specialization level?

In practice, a country that needs information on its comparative advantage patterns for designing development strategies may not have the luxury to wait for the patterns to be revealed.

One merit of the RCA approach is that it provides a systematic framework for comparing a variety of structural differences across countries. Such comparison could provide valuable information for policy guidance. In addition, data for RCA analysis are much more easily available than for the DRC/BC approach.

2.4.3 A terminology issue

While comparative advantage/disadvantage is a common categorization, applying the label "disadvantage" on industries with RCA indices less than unity or DRC ratios greater than unity seems to convey unnecessarily negative connotations. Besides, these categorizations also result inconvenient when comparative advantage variations are discussed. Therefore, we suggest replacing the "comparative advantage/disadvantage" categorization with "strong/weak comparative advantage". That is, RCA indices greater than one (or DRC ratios less than one) are indication of strong comparative advantage, while RCA indices less than one (or DRC ratios greater than one) indicate weak comparative advantage.

2.4.4 DRC/BC and RCA: policy applications

The DRC/BC and RCA approaches can provide useful and complementary information for commercial and policy decision-making regarding aquaculture

development. DRC ratios can provide information about the true economic viability and resource utilization efficiency of aquaculture activities, which is useful for determining aquaculture development priorities. Other factors remaining constant, priority should be given to those aquaculture activities with relatively low DRC ratios because such activities not only use domestic resources more efficiently, but also tend to be more economically viable due to their relatively large profit margins.

However, there are two caveats for using DRC ratios as policy guidance. First, it is important to bear in mind that DRC ratios may reflect short-term comparative advantage subject to changes over time. Second, when an aquaculture activity is identified as having a high DRC ratio (i.e. low resource utilization efficiency), a proper policy reaction is not to simply give it a low development priority, but to identify the underlying causes of the low efficiency and implement the appropriate correctives.

In sum, the relative and dynamic nature of comparative advantage should always be borne in mind when DRC ratios are used as a comparative advantage indicator.

Discretion is also needed when using the RCA approach. A country can use RCA analysis to examine the transition of its aquaculture industrial structure and compare it to other countries. Such examination and comparison can help the country detect whether its aquaculture development is consistent with its underlying comparative advantage patterns. For example, after RCA analysis helps identify a country's distinct specialization features (as compared to other countries), further research (e.g. DRC/BC analysis) can be conducted to examine whether these distinct features reflect the country's comparative advantage or represent a deviation from its optimal specialization pattern due to historical inertia, policy distortions, or other obstacles.

The RCA approach is especially useful for a country whose aquaculture is still at its "infancy" stage. This is so because, by providing a systematic comparison of aquaculture development experiences in other countries, RCA analysis gives the newcomer a "comparative advantage" to learn from these experiences. For example, when designing its aquaculture development strategy, a country would like to refer to the comparative advantage patterns of other countries that have similar resource endowment structure and other features. Understanding the driving forces behind these patterns and their transition can help the country avoid making similar mistakes and design a more sensible aquaculture development blueprint.

In the following two sections we apply the RCA approach to evaluate countries' comparative advantage in different aquaculture activities. We do not illustrate the application of the DRC/BC approach in this study, primarily because of a lack of data on aquaculture production costs. Table 2 provides a template for basic data needed to apply the DRC/BC approach. In addition, the DRC approach is well established in

TABLE 2
Data template for the DRC/BC approach

Basic information	Farming characteristics	Revenue	Costs
Country	Farm area (ha)	Production quantity (kg/year)[2]	Operating cost (USD or LCU/kg)3
Time period	Farming cycles[1] (No.)	Farm price (USD or LCU/kg)2	Total cost (USD or LCU/kg)3
Species name	Stocking density (fingerling/ha)1	Revenue (USD or LCU)	% of total cost to total revenue
Data sources	Yield (kg/ha/year)1		% of operating cost to total revenue
			% of operating cost to total cost
			% of wage cost to operating cost
			% of feed cost to operating cost
			% of seed cost to operating cost
			% of energy cost to operating cost

[1] Average or range.
[2] Quantity and price are for live weight, live-weight equivalent, or otherwise specified. LCU = local currency unit.
[3] Total cost = fixed cost (e.g. depreciation) + operating cost (including wage, feed, seed, energy, and other variable costs)

the literature and has several empirical references related to aquaculture (Ling, Leung and Shang, 1999; Lee *et al.*, 2003; Kaliba and Engle, 2003) and agriculture (Odhiambo, Kristjanson and Kashangaki, 1996; Hassan *et al.*, 1999; Jooste and van Zyl, 1999; Magagula and Faki, 1999; Nakhumwa *et al.*, 1999; Saasa *et al.*, 1999; USAID, 1999; Mucavele, 2000; Sukume *et al.*, 2000).