Annex 3: Formal Specifications of Competitiveness Measures

A. DRC Ratios

The formal definition of the DRC\textsuperscript{199} is:

\begin{equation}
\text{DRC} = \sum(D*P_d)/(W_p - \sum a_{ji}W_{pj})
\end{equation}

where \(i\) and \(j\) refer to internationally traded output and inputs respectively and \(W_p\) is their world price; \(a_{ji}\) is the units of input \(j\) per unit of \(i\). \(D\) is set of domestic factors of production required to produce a unit of \(i\) and \(P_d\) is their economic or shadow price value. In theory, all indirectly traded inputs into good(s) used to produce \(i\) should be included in the denominator with a negative sign as part of \(\sum j\).

Economic efficiency requires that DRC be less than the long-run value of foreign exchange to the economy (the shadow exchange rate).

Benefits in this analysis are solely in terms of foreign exchange. However, in principle, it is also possible to incorporate additional external effects either positive or negative. Where these can be converted into an equivalent value in foreign currency (\(E\)), the DRC becomes:

\begin{equation}
\text{DRC} = \sum(D*P_d)/(W_p - \sum a_{ji}W_{pj}) + E
\end{equation}

where \(E\) can be either positive or negative.

The analysis used in this report is compatible with project calculations as in the standard literature\textsuperscript{200} where for a project producing internationally traded output and using internationally traded and non-traded inputs and labor, economic net benefits in a single year valued at domestic prices (EB) can be expressed as:

\begin{equation}
\text{EB} = (T_o - T_i) \times (\text{SER}) - (\text{NT}_s + \text{NT}_d + L)
\end{equation}

\textsuperscript{199} The classic statement of this approach is Bruno (1972).

\textsuperscript{200} UNIDO (1972), Little and Mirrlees (1974) and Squire and van der Tak (1975).
where $T_o$ and $T_i$ are the border value of traded output and inputs, respectively, $SER$ is the shadow value of the exchange rate, $NT_s$ and $NT_d$ are non-traded inputs taken from the supply margin and demand margin, respectively, and $L$ is labor.

All values are in domestic currency, and $SER$ is the shadow exchange rate. $L$ should be valued at the shadow wage, $NT_s$ at the economic cost of supply and $NT_d$ at willingness to pay for the diverted inputs. In the standard DRC version shown in Figure 1, capital cost is an annual charge, which should be decomposed into traded goods, non-traded goods and labor.

Efficiency using the calculation in Figure implies $EB > 1$, which can be rearranged as an alternative measure of efficiency as follows:

**Figure 8: Calculation of Alternative Measure of Efficiency for Economic Net Benefits**

\[
\frac{(NT_s + NT_d + L)}{(T_o - T_i) \times (SER)} < 1
\]

This is the DRC ratio used in the analysis of this report.

A rigorous version of Figure would further decompose non-traded items in variable supply ($NT_s$) into traded goods and labor with the former traded inputs into non-traded goods deducted from the denominator. This report does not introduce these complications and adopts the further simplifying assumptions:

1) Initially $SER$ equals the current actual exchange rate (OER);  
2) All non-traded inputs are expandable at the supply margin, so economic value is determined by their cost of production not willingness to pay, so $NT_d = 0$;  
3) The shadow wage and the actual wage are equal; and  
4) There are no externalities.

The economic supply cost for $NT_s$ is approximated by adjusting for first-round effects; indirect taxes are deducted from $NT_s$ and traded inputs into the non-traded sectors are included in the denominator under $T_i$. Thus this version of the DRC is:

**Figure 9: Calculation of Domestic Resource Cost Adjusted for First-round Effects**

\[
DRC = \frac{(NT_s + L)}{(T_o - T_i) \times OER}
\]

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201 This is the reason why (ignoring non-traded goods in fixed supply) Little and Mirrlees (1974:363) characterized the DRC approach as ‘the labor cost per unit of foreign exchange saving’.
This is an approximation but it is consistent with the commonly used simple efficiency measure in operational economic appraisals. There EB is often calculated as shown in Figure 2:

**Figure 20: Commonly Used Simple Efficiency Measure of Economic Benefit**

\[
EB = (T_i - T_o) \times (SER) - (NTs + L)
\]

where labor may or may not be valued at a shadow wage, and domestic inputs are treated as non-traded goods in variable supply whose value is determined by deducting taxes from market prices. Subsequent calculations can test the results for alternative assumptions about the value of foreign exchange.

The shadow exchange rate (SER) is the key parameter for testing efficiency or inefficiency in the DRC approach. The shadow exchange rate is interpreted here as the long-run value of foreign currency to an economy. The DRC analysis compares this with the estimated cost in domestic resources per unit of foreign exchange to establish if there is a net welfare benefit. Applied project analysis with the SER typically utilizes tariff and subsidy data to estimate the difference between domestic and world prices in the economy (as explained in the text), and then the shadow exchange rate ratio (or premium on foreign exchange) becomes as shown in Figure 3:

**Figure 31: Calculation of Shadow Exchange Rate Ratio**

\[
\frac{SER}{OER} = \sum \mu_i(1 + t_i - s_i) + \sum \mu_j(1 - t_j + s_j)
\]

where for import good i and export good j, \(\mu_i\) and \(\mu_j\) are share of good i and j, respectively, in the value of additional foreign exchange made available by a project, t and s refer to import or export taxes and subsidies, and the summation refers to all traded goods affected.

Theoretically the trade shares \(\mu_i\) and \(\mu_j\) are the value of additional importable and exportable goods made available as a result of the change in the exchange rate created by extra foreign exchange and will be determined by the price elasticities of demand for different goods. Simple applications often assume elasticities are equal for each product.

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202 In the cost benefit literature it is defined as the addition to welfare generated by the availability of one extra unit of foreign exchange made available by the activity or project under consideration. Londero (2003) Chapter 2 has an extensive discussion of the shadow exchange rate from a project perspective with both a general equilibrium derivation and a discussion of simple operational formulae.

203 Figure 3 is equivalent to the classic definition of the shadow price of foreign exchange in Harberger (1973).
This analysis has the potentially serious limitation of ignoring long-term real exchange rate adjustments. Where the current exchange rate of an economy does not reflect the rate necessary for long-run internal and external balance, the long-run equilibrium real exchange rate must be used to derive the SER for use in DRC analysis. When an underlying disequilibrium is introduced, the expression in Figure 3 must be modified to become the calculation as shown in Figure:

**Figure 12: Calculation of Shadow Exchange Rate Ratio in Conditions of Exchange Rate Disequilibrium**

\[
\text{SER/OER} = \left( \frac{\text{EER}}{\text{OER}} \right) \left( \sum \mu_i (1 + t_i - s_i) + \sum \mu_j (1 - t_j + s_j) \right)
\]

where EER is the long-run equilibrium real exchange rate.

This simplifies to:

**Figure 43: Simplified Calculation of Shadow Exchange Rate in Conditions of Exchange Rate Disequilibrium**

\[
\text{SER} = \text{EER} \times \left( \sum \mu_i (1 + t_i - s_i) + \sum \mu_j (1 - t_j + s_j) \right)
\]

where Figure 4 defines the SER as the long-run equilibrium real exchange rate adjusted for the net effect of tariffs and subsidies on trade that raises domestic prices above world levels. The ratio of the EER to the OER can be interpreted as the future depreciation or appreciation of the exchange rate necessary for long-run internal and external balance.

In recent years, the incidence of tariffs, taxes and subsidies on trade has declined significantly for most economies. In practice, for the majority of countries, this report suggests that the SER for use in the DRC analysis can be based on an estimate of the long-run equilibrium real exchange rate, as in practice changes in EER relative to the actual exchange rate are likely to dominate the net effect of trade taxes and subsidies. This is not an easy parameter to estimate, and in practice it may have to be used as part of sensitivity analysis testing the implications of different values on efficiency. However, where average import tariffs remain high, there will be a need incorporate these in the full expression for the SER.

There is a close similarity between the DRC indicator and the effective rate of protection. Where there is no shadow pricing of domestic resources or foreign exchange (so SER = OER) and non-traded inputs are treated as part of value added, the equivalence is that value added at domestic prices equals domestic resource costs and value added at world

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204 Edwards (1991) develops the concept of an equilibrium real exchange rate based on a set of underlying fundamental factors affecting an economy; Chudik and Mongardini (2007) and Hobdari (2008) are recent empirical applications of this approach in the African context.
prices equals net foreign exchange. This means that the effective rate of protection (ERP) is as noted in Figure:

**Figure 14: Calculation of Effective Rate of Protection**

\[
ERP = \frac{(VAdp - VAwp)}{VAwp} \text{ or } \frac{VAdp}{VAwp} - 1
\]

where value added at world prices (VAwp) is equivalent to \((To - Ti)*OER\) in Figure, and value added at domestic prices (VAdp) is equivalent to \((NTs + L)\) in Figure.

From the expression in Figure, \(DRC = \frac{(NTs + L)}{(To - Ti)*OER}\), so:

**Figure 15: Calculation of Domestic Resource Cost and Effective Rate of Protection Given Value Added**

\[
DRC = \frac{VAdp}{VAwp}
\]

\[
ERP = DRC - 1.
\]

This has the implication that efficient activities where \(DRC < 1\) will have a negative ERP, or in other words protection on output will be less than protection on inputs, so value-added with protection is less than what it would be in a free trade situation.

When tariff rates are used to proxy the differences between world and domestic prices, and there is no further shadow price adjustment to domestic resources, implicitly the analysis is calculating effective rates of protection.

**B. Trade Structure Indicators**

The idea that the output and trade structure of poor countries matters for their economic performance has a long history in development economics and is linked with discussions of the importance of industrialization. Recent literature has formalized this approach by stressing the need to upgrade the export structure of poor countries to higher levels of technological content. The starting point for analysis is the existing pattern of specialization based on the Revealed Comparative Advantage (RCA) measure for product \(i\) and country \(j\), as shown in Figure.

**Figure 16: Calculation of Revealed Comparative Advantage Measure for a Given Product and Country**

\[
RCA_{ij} = \frac{(Xij/Xtj)}{(Xit/Xwt)}
\]

where \(X\) is exports, \(w\) is the world and \(t\) is total.
Thus RCAij is the share of i in the total exports of country j divided by the share of i in total world exports. Thus a RCA > 1 implies the country is more specialized in a product than is the world economy as whole, and the higher the RCA, the greater is the degree of specialization. The argument is that different patterns of specialization have different implications for growth, and that poor countries need to upgrade their export structure into higher value, technologically more sophisticated products, where it is anticipated demand prospects on the world market will be stronger.

The analysis was advanced by path-breaking work by Lall (2000) which created a taxonomy of products based on a combination of earlier data on their R&D intensity (that is R&D costs as a proportion of sales value) and personal knowledge of industrial processes, which has been used widely to classify export structure. This work groups exports into nine technology categories by the R&D intensity measure. The vast majority of manufactured exports from most of sub-Saharan Africa are in the low technology, labor-intensive and natural resource-based categories, with little in the medium and high technology categories. For example, for Ethiopia in 2009, manufactured exports were dominated by leather and footwear (57%), food and beverages (25%) and textiles (12%), which are either natural resource-based or simple labor-intensive goods.

A limitation of this analysis is that it does not allow for a distinction between production processes and products, since even relatively technologically advanced goods still can have simple labor-intensive stages in their production. In response to this, Lall, Weiss and Zhang (2006) attempted to differentiate between products at the disaggregate level and to create an index (calculated at the 4-digit level) to capture their sophistication. This was done for 766 individual product categories by taking a weighted average of the incomes of all exporters of the good concerned with the weights given by their share in total world trade in the good. Hence the calculation in Figure:

**Figure 17: Calculation of Sophistication Index for a Good**

\[ SI_i = \sum \left( \frac{X_{ik}}{X_{iw}} \right) Y_k \]

where \( SI_i \) is the sophistication index for good i, \( X_{ik} \) is exports of i from country k, \( X_{iw} \) is world exports of i, \( Y_k \) is income per capita in country k and summation is for all k.

Lall, Weiss and Zhang (2006) use SI in various ways, including country ranking at the aggregate level (where SI is aggregated over all products in total trade), for comparing technology classifications and for establishing patterns within broad categories like textiles and electronics. The rationale is that within individual product categories, the average income of exporting countries can be a useful proxy for the technological depth.
of a product; hence an electrical good from Japan may be deemed to have higher technology content than the same good from the Philippines. Similarly, within apparel, products exported by rich countries – or processes undertaken by them – are taken to be more skill, technology or marketing intensive and to yield higher profit margins and wages than the more standardized goods exported by poorer countries.

Independently, Hausmann, Hwang and Rodrik (2007) applied the same approach, but using a different weighting system. Here PROD represents the income level of a particular good (calculated at the 6-digit level), but unlike the SI, the weights used are the revealed comparative advantage of each country in the good concerned. Hence:

**Figure 58: Calculation of Income Level for a Good**

\[
\text{PRODi} = \sum ((X_{ik}/X_{tk})/(X_{iw}/X_{tw}))*Y_k
\]

where PRODi is the income level for good i, as before X_{ik} is exports of i from country k, X_{iw} is world exports of i, Y_k is income per capita in country k and summation is for all k. In addition, X_{tk} is the total exports of country k, and X_{tw} is total world exports.

The expression in Figure 5 can be rearranged as follows:

**Figure 19: Alternative Calculation of Income Level for a Good**

\[
\text{PRODi} = \sum ((X_{ik}/X_{iw})*(X_{tw}/X_{tk}))*Y_k
\]

The weights that result from the expression in brackets in Figure are then normalized to sum to unity. The difference from the procedure in Figure is that now the share of country k in world trade in product i is multiplied by the inverse of country k’s share in total world trade. This has the effect, which is intentional, of giving a higher weight to goods exported from small countries. Hence, in this view, even if the US exports more shirts than, say Bangladesh, if shirts are a product in which Bangladesh has specialized, but the US has not, the US exports should be seen as a low productivity product.

Hausmann, Hwang and Rodrik (2007) apply their PROD indicator to total trade of individual countries to calculate an overall measure akin to the sophistication index. What they term the ‘productivity level of an economy’s export basket’ (EXPY) is a weighted average of PROD for all commodities with the weights given by their share in a country’s trade. Their focus is on long-term trends, and they relate EXPY to growth performance over time and contrast actual EXPY with that expected for an economy’s income level.
African countries have the lowest EXPY score in their sample. For example, for 2001, the values for Niger and Ethiopia are US$2,398 and US$2,715, respectively (in 2000 US dollars), as compared with the highest score in the sample of US$24,552 for Luxembourg. When they incorporate their productivity of exports measure in a growth analysis, they find that, when controlling for a range of other factors, countries with a low productivity export basket grow more slowly.

The policy implication of this analysis is that it is important to look to ways of raising the technological sophistication and productivity levels of production, and exports even if in the short-term it may appear to run counter to comparative advantage. In terms of the DRC analysis, this can be interpreted as a distinction between a medium-run and a long-run DRC. However, there will be many new products to which a poor country realistically cannot aspire to produce, so its DRC is unacceptably high. The difficulty of moving into a new product is linked directly with the degree of specificity of the assets, capabilities and operating environment (such as the physical assets, labor skills, technological knowledge and infrastructure needs) associated with the products in which a country currently is specialized. Where these attributes are either very general – i.e., relevant for the production of a wide range of goods – or production conditions are similar in the new products, the transition to a new specialization may be relatively easy. For any economy, there will be some ‘new goods,’ in which the economy does not currently specialize but which are relatively easy into which to move. These are ‘nearby’ products where economic distance is low due to the similarity of the assets and capabilities the products require relative to those needed by the economy’s current pattern of specialization.

The concept of economic distance is developed formally by Hausmann and Klinger (2006) who calculate the probability that two countries both will have a comparative advantage in different pairs of products. The higher the probability, the lower is the distance between the two products. If products are grouped by broad classifications, some are found to be peripheral in the sense that distance is low within the group but high between the group and others. These peripheral groups typically are primary products, but also include garments.

An important insight of the PROD and SI indicators are that they reveal that, even within what are generally low productivity or unsophisticated groups (like textiles or clothing for example), there will be some product lines with higher than average PROD or SI scores, and it may be relatively easy for poor countries to move into production of higher-scoring product lines. This shift into ‘nearby’ products is a relatively easy way of raising the overall EXPY score for a country and is something to be supported by policy. For example, using 2006 US dollars, UNIDO (2011) shows that within the HS Code for
clothing, the PROD score ranges from US$5,316 (HS 8464 under garments) to US$11,066 (HS 8482 other apparel). Hence, there is scope for upgrading production in similar product lines to those in which most poor economies are already operating. Screening at the sub-sector level will not be able to distinguish these higher productivity ‘nearby’ products, and for this, individual market studies will be needed.