The : and :: Relations

$$\frac{\texttt{triv x}}{\texttt{x} : \mathit{Triv}} \tag{1}$$

$$\frac{\texttt{triv x}}{\texttt{x} :: \mathit{Box}(\mathit{Triv})} \tag{2}$$

$$\frac{\texttt{int x}}{\texttt{x} : \mathit{Int}} \tag{3}$$

$$\frac{\texttt{int x}}{\texttt{x} :: \mathit{Box}(\mathit{Int})} \tag{4}$$

$$\frac{\texttt{x} :: \mathit{Box}(\mathcal{T})}{\texttt{immut x} :: \mathit{Immut}\ \mathit{Box}(\mathcal{T})} \tag{5}$$

$$\frac{\texttt{x} :: \mathcal{T} \qquad \mathit{Box}?(\mathcal{T})}{\texttt{ref x} :: \mathit{Box}(\mathcal{Ref}\ \mathcal{T})} \tag{6}$$

$$\frac{\texttt{x} :: \mathcal{T} \qquad \mathit{Box}?(\mathcal{T})}{\texttt{(x)} :: \mathcal{T}} \tag{7}$$

$$\frac{\texttt{x} :: \mathcal{T} \qquad \mathit{Box}?(\mathcal{T})}{\texttt{\& x} : \mathcal{Ref}\ \mathcal{T}} \tag{8}$$

$$\frac{\texttt{x} :: \mathcal{Ref}\ \mathcal{T}}{\texttt{x @} : \mathcal{T}} \tag{9}$$

$$\frac{\texttt{x} : \mathcal{Ref}\ \mathcal{T}}{\texttt{x @} : \mathcal{T}} \tag{10}$$

$$\frac{\texttt{x} :: \mathit{Box}(\mathcal{T}) \qquad \texttt{y} :: \mathcal{U} \qquad \mathcal{T} <: \mathcal{U}}{\texttt{x := y} : \mathit{Box}(\mathcal{T})} \tag{11}$$

$$\frac{\texttt{x} :: \mathit{Box}(\mathcal{T}) \qquad \texttt{y} :: \mathcal{U} \qquad \mathcal{T} <: \mathcal{U} \qquad \mathit{Box}?(\mathcal{U})}{\texttt{x := y} : \mathit{Box}(\mathcal{T})} \tag{12}$$

$\texttt{x} : \mathcal{T}$ is read as "expression $\texttt{x}$ is of type $\mathcal{T}$ and is in an *r-context*."
$\texttt{x} :: \mathcal{T}$ is read as "variable $\texttt{x}$ is of type $\mathcal{T}$ and is in an *l-context*."
The operators could also be referred to as the "r-type of" and "l-type of" operators.

l-context denotes everything that is *assignable* (indicated as a storable memory). r-context, on the other hand, denotes everything that is *expressible* (can be produced by an expression).

There is no r-value (e.g. expression) of the type $\mathit{Box}(\mathcal{T})$.

We omit rules for Con types as they only operate on r-values.

We omit rules for $\mathcal{Fun}$ types as they only accept r-values. Any variable and/or primitive type has both r-value and l-value (when it comes to primitive types, only r-value). In all cases, the r-value part of the actual parameter is passed when the function is being called.

The $<:$ Relation

$$\frac{}{Box(Triv) <: Box(Triv)} \tag{13}$$

$$\frac{}{Box(Int) <: Box(Int)} \tag{14}$$

$$\frac{T <: Box(U) \qquad Box?(T)}{T <: Immut\ Box(U)} \tag{15}$$

$$\frac{Box(T) <: Immut\ Box(U)}{immut\ Box(T) <: Immut\ Box(U)} \tag{16}$$

$$\frac{T <: U \qquad Box?(T) \qquad Box?(U)}{Ref\ T <: Ref\ U} \tag{17}$$

$Box?$ statement checks for both mutable and immutable containers. In other words, $Box(Int)$ and $immut\ Box(Int)$ would both satisfy the $Box?$ condition.