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$$\mathcal{U}(\lambda S, \lambda V, \lambda N_1, \dots) = \lambda \mathcal{U}(S, V, N_1, \dots)$$

$$\frac{d}{d\lambda}\{ \quad \}$$

$$= \mathcal{U}(S, V, N, \dots) \frac{d\lambda}{d\lambda}$$

$$= \mathcal{U}(S, V, N, \dots)$$

$$\left(\frac{\partial \mathcal{U}}{\partial(\lambda S)}\right)\left(\frac{\partial(\lambda S)}{\partial \lambda}\right) d\lambda + \dots + \left(\frac{\partial \mathcal{U}}{\partial(\lambda N)}\right)\left(\frac{\partial(\lambda N)}{\partial \lambda}\right) d\lambda =$$

$$\frac{1}{d\lambda} \quad \left\{\left(\frac{\partial \mathcal{U}}{\partial \lambda S}\right)\left(\frac{\partial(\lambda S)}{\partial \lambda}\right) + \dots + \left(\frac{\partial \mathcal{U}}{\partial(\lambda N)}\right)\left(\frac{\partial(\lambda N)}{\partial \lambda}\right)\right\} d\lambda =$$

$\downarrow S \qquad \downarrow N$

$$\left(\frac{\partial \mathcal{U}}{\partial(\lambda S)}\right) \cdot S + \dots + \left(\frac{\partial \mathcal{U}}{\partial(\lambda N)}\right) \cdot N =$$

$\lambda = 1$

$$\left(\frac{\partial \mathcal{U}}{\partial S}\right) \cdot S + \left(\frac{\partial \mathcal{U}}{\partial V}\right) \cdot V + \dots + \left(\frac{\partial \mathcal{U}}{\partial N}\right) \cdot N =$$

$\downarrow T \qquad \downarrow -p \qquad \downarrow \mu$

$$T \cancel{d}S - p \cancel{d}V + \sum_{K=1}^{N-2} \mu_K \cancel{d}N_K = \mathcal{U}(S, V, N_1, \dots)$$

$$\sum_{K=0}^{N} P_K X_K = \mathcal{U}$$

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$$\sum_{K=0}^{N} F_K X_K = S$$

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