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ONLINE APPENDIX

ADB Economics Working Paper No. 660

A SIMPLE MODEL OF INTERNAL AND EXTERNAL BALANCE FOR RESOURCE-RICH DEVELOPING COUNTRIES

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APPENDIX

A. Model of Internal and External Balance for Resource-Rich Developing Countries

Consumption, imports, and taxes all depend on gross national income and so:

$$C = a + c(1-t)Y_{GNI}$$

$$IM = m(\theta)(1-t)Y_{GNI}$$

$$T = tY_{GNI}$$

As noted in the main text, the government levying taxes on gross national income of $T = tY_{GNI}$ is equivalent to the government returning only $(1-t)\tilde{\alpha}Y_R$ of the total take to domestic factors of production, retaining the remainder $(t\tilde{\alpha}Y_R)$ and then just taxing non-resource income at rate t . We take investment, I , to be exogenous. The income-expenditure identity dictates that $Y_{NR} \equiv C + I + G + EX_{NR} - IM$ and:

$$Y_{NR} = a + c(1-t)Y_{GNI} + I + G + EX_{NR}(\theta) - m(\theta)(1-t)Y_{GNI} \quad (7)$$

Given that $Y_{GNI} = Y_{NR} + \tilde{\alpha}Y_R$ then equation 7 simplifies to:

$$Y_{NR} = \mu(A + EX_{NR}(\theta)) + (\mu - 1)\tilde{\alpha}EX_R \quad (8)$$

where absorption $A = a + I + G$, the multiplier is $\mu = \frac{1}{1-(c-m)(1-t)}$ and $(\mu - 1) = \frac{(c-m)(1-t)}{1-(c-m)(1-t)} > 0$ since $c > m(\theta)$ for all θ by assumption. An increase in government take, $\tilde{\alpha}$, leads to an increase in non-resource output:

$$\frac{dY_{NR}}{d\tilde{\alpha}} = (\mu - 1)EX_R > 0$$

This is so because an increase in $\tilde{\alpha}$ leads to an increase in gross national income and through that an increase in C and IM , and since $\mu - 1 > 0$ then $\frac{dY_{NR}}{d\tilde{\alpha}} > 0$. Full employment in the non-resource sector is given by:

$$Y_{NR}^f = F_{NR}(K_{NR}^*, L_{NR}^*)$$

where K_{NR}^* and L_{NR}^* are the full employment levels of domestic capital and labor. The internal balance condition is therefore:

$$Y_{NR}^f = \mu(A + EX_{NR}(\theta)) + (\mu - 1)\tilde{\alpha}EX_R \quad (9)$$

External balance is defined by the sustainable level of the current account, which we define as $CA = 0$. The current account is given by the sum of net exports and net factor income (NFI). In our economy, given the negative value of NFI, then:

$$\begin{aligned}
CA &= EX_{NR}(\theta) + EX_R - IM - (1 - \tilde{\alpha})EX_R \\
&= EX_{NR}(\theta) + \tilde{\alpha}EX_R - m(\theta)(1-t)Y_{GNI}
\end{aligned}$$

which, substituting for $Y_{GNI} = Y_{NR} + \tilde{\alpha}EX_R$, simplifies to the expression for external balance in the main text:

$$(1 - c(1 - t))(EX_{NR}(\theta) + \tilde{\alpha}EX_R) - m(\theta)(1 - t)A = 0 \quad (10)$$

Equations 9 and 10 constitute our economic system with two equations (internal and external balance) and two unknowns: the real exchange rate (RER), θ , and absorption, A . This may be written as follows:

$$\begin{pmatrix} 1 & 1 \\ (1 - c(1 - t)) & -m(\theta)(1 - t) \end{pmatrix} \begin{pmatrix} EX_{NR}(\theta) \\ A \end{pmatrix} = - \begin{pmatrix} \frac{1}{\mu}Y_{NR}^f - \frac{(\mu-1)}{\mu}\tilde{\alpha}EX_R \\ (1 - c(1 - t))\tilde{\alpha}EX_R \end{pmatrix} \quad (11)$$

Solving for $EX_{NR}(\theta)$ and A gives:

$$EX_{NR}(\hat{\theta}) = m(\hat{\theta})(1 - t)(Y_{NR}^f + \tilde{\alpha}EX_R) - \tilde{\alpha}EX_R \quad (12)$$

$$\hat{A} = (1 - c(1 - t))[Y_{NR}^f + \tilde{\alpha}EX_R] \quad (13)$$

where $\hat{\theta}$ is the equilibrium RER and \hat{A} is the equilibrium level of absorption.

Since $EX'_{NR}(\theta) > 0$, the LHS of equation 12 is increasing in θ , while, since $m'(\theta) < 0$, the RHS of equation 12 is decreasing in θ . This ensures that equation 12 yields a unique solution for $\hat{\theta}$.

Differentiating equations 9 and 10 with respect to θ , A and $\tilde{\alpha}$ gives the system:

$$\begin{aligned}
&\begin{pmatrix} \frac{dEX_{NR}(\theta)}{d\theta} - (1 - t)\frac{dm}{d\theta}(Y_{NR}^f + \tilde{\alpha}EX_R) & 1 \\ (1 - c(1 - t))\frac{dEX_{NR}(\theta)}{d\theta} - \frac{dm}{d\theta}(1 - t)A & -m(\theta)(1 - t) \end{pmatrix} \begin{pmatrix} d\hat{\theta} \\ d\hat{A} \end{pmatrix} \\
&= - \begin{pmatrix} \frac{(\mu-1)}{\mu}EX_R \\ [1 - c(1 - t)]EX_R \end{pmatrix} d\tilde{\alpha}
\end{aligned} \quad (14)$$

which allows, using Cramer's rule, the determination of the following results.

Proposition 1. Following an increase in the government take, $\tilde{\alpha}$, the equilibrium RER, $\hat{\theta}$, must appreciate to maintain internal and external balance, where:

$$\frac{d\hat{\theta}}{d\tilde{\alpha}} = - \frac{1}{\frac{EX_{NR}}{\theta} \left(\varepsilon_{EX_{NR}, \theta}(\hat{\theta}) + \frac{1}{s_{NR}(\hat{\theta})} \varepsilon_{m, \theta}(\hat{\theta}) \right)} EX_R [1 - m(\hat{\theta})(1 - t)] < 0$$

Proof: From equation 14, using Cramer's rule then:

$$\begin{aligned} \frac{d\hat{\theta}}{d\tilde{\alpha}} &= \frac{1}{\Delta} \begin{vmatrix} -\left(\frac{\mu-1}{\mu}\right)EX_R & 1 \\ -[1-c(1-t)]EX_R & -m(\hat{\theta})(1-t) \end{vmatrix} \\ &= -\frac{1}{\left(\frac{dEX_{NR}(\hat{\theta})}{d\theta}\right) - (1-t)(Y_{NR}^f + \tilde{\alpha}EX_R) \frac{dm(\hat{\theta})}{d\theta}} EX_R [1 - m(\hat{\theta})(1-t)] \\ &= -\frac{1}{\frac{EX_{NR}}{\theta} \left(\varepsilon_{EX_{NR},\theta}(\hat{\theta}) + \frac{1}{s_{NR}(\hat{\theta})} \varepsilon_{m,\theta}(\hat{\theta}) \right)} EX_R [1 - m(\hat{\theta})(1-t)] < 0 \end{aligned}$$

where:

$$\begin{aligned} \varepsilon_{EX_{NR},\theta}(\hat{\theta}) &= \frac{\hat{\theta}}{EX_{NR}(\hat{\theta})} \frac{dEX_{NR}(\hat{\theta})}{d\theta} > 0 \\ \varepsilon_{m,\theta}(\hat{\theta}) &= -\frac{\hat{\theta}}{m(\hat{\theta})} \frac{dm(\hat{\theta})}{d\theta} > 0 \\ s_{NR}(\hat{\theta}) &= \left(\frac{EX_{NR}(\hat{\theta})}{EX_{NR}(\hat{\theta}) + \tilde{\alpha}EX_R} \right) \\ \Delta &= \begin{vmatrix} \frac{dEX_{NR}(\hat{\theta})}{d\theta} - (1-t) \frac{dm(\hat{\theta})}{d\theta} (Y_{NR}^f + \tilde{\alpha}EX_R) & 1 \\ (1-c(1-t)) \frac{dEX_{NR}(\hat{\theta})}{d\theta} - \frac{dm(\hat{\theta})}{d\theta} (1-t)\hat{A} & -m(\hat{\theta})(1-t) \end{vmatrix} \\ &= -\frac{1}{\mu} \left(\frac{dEX_{NR}(\hat{\theta})}{d\theta} - (1-t)(Y_{NR}^f + \tilde{\alpha}EX_R) \frac{dm(\hat{\theta})}{d\theta} \right) < 0 \end{aligned}$$

Proposition 2. Following an increase in the government take, $\tilde{\alpha}$, the equilibrium level of absorption, \hat{A} , must increase to maintain internal and external balance, where:

$$\frac{d\hat{A}}{d\tilde{\alpha}} = \frac{EX_R}{\frac{EX_{NR}}{\theta} \left(\varepsilon_{EX_{NR},\theta}(\hat{\theta}) + \frac{1}{s_{NR}(\hat{\theta})} \varepsilon_{m,\theta}(\hat{\theta}) \right)} \begin{bmatrix} (1-c(1-t)) \frac{dEX_{NR}(\hat{\theta})}{d\theta} \\ -\hat{A}(1-t) \frac{dm(\hat{\theta})}{d\theta} \end{bmatrix} > 0$$

Proof: From equation 14, using Cramer's rule:

$$\frac{d\hat{A}}{d\tilde{\alpha}} = \frac{1}{\Delta} \begin{vmatrix} \frac{dEX_{NR}(\hat{\theta})}{d\theta} - (1-t)\frac{dm}{d\theta}(Y_{NR} + \tilde{\alpha}EX_R) & -\left(\frac{\mu-1}{\mu}\right)EX_R \\ (1-c(1-t))\frac{dEX_{NR}(\hat{\theta})}{d\theta} - \frac{dm(\hat{\theta})}{d\theta}(1-t)\hat{A} & -[1-c(1-t)]EX_R \end{vmatrix}$$

$$= \frac{EX_R}{\frac{EX_{NR}}{\theta} \left(\varepsilon_{EX_{NR},\theta(\hat{\theta})} + \frac{1}{s_{NR}(\hat{\theta})} \varepsilon_{m,\theta(\hat{\theta})} \right)} \begin{pmatrix} (1-c(1-t))\frac{dEX_{NR}(\hat{\theta})}{d\theta} \\ -\hat{A}(1-t)\frac{dm(\hat{\theta})}{d\theta} \end{pmatrix} > 0$$

B. Calculation of Government Take and Net Factor Income

The production function for the resource sector is:

$$Y_R = F_R(K_R, L_R, R)$$

where K_R and L_R are capital and labor in the resource sector and R is the resource. Both K_R and L_R are foreign. Total factor payments to capital and labor are $wL_R + rK_R$ where w and r are the wage and rental rate, which are determined exogenously to the domestic economy. Thus, resource rents (total output net of the cost of factors of production) are:

$$\rho = Y_R - wL_R + rK_R$$

The government owns share α of the resources sector and foreign multinational firms (MNFs) own share $(1 - \alpha)$. Thus, resource rents are shared between the two groups in these proportions. In addition, the government taxes the foreign share of rents at rate t_R and charges MNFs royalties on resource sector output at rate t_L . The government's share of rents is thus $(\alpha + t_R(1 - \alpha))\rho$ and its total royalty receipts are $t_L Y_R$. It follows that the MNFs share of rents is $(1 - t_R)(1 - \alpha)\rho$.

Given that the ratio of resource rents, ρ , to resource sector output, Y_R , is $Y = \rho/Y_R$, then the share of rents of the government may be calculated as $(\alpha + t_R(1 - \alpha))Y Y_R$. Therefore, the total revenue of the government from the resource sector is $(t_L + (\alpha + t_R(1 - \alpha))Y)Y_R$. From this, the government take, $\tilde{\alpha}$, which is the ratio of total resource revenue to resource sector output, is defined by:

$$\tilde{\alpha} = t_L + (\alpha + t_R(1 - \alpha))Y$$

To calculate NFI, we sum the payments to foreign factors of production ($wL_R + rK_R$) plus MNFs share of resource rents $(1 - \alpha)\rho$ less taxes on those rents $(t_R(1 - \alpha)\rho)$ less royalty payments ($t_L Y_R$). This sums to:

$$NFI = (1 - Y - t_L + (1 - t_R)(1 - \alpha)Y)Y_R$$

which, given the definition of $\tilde{\alpha}$ above, simplifies to $NFI = (1 - \tilde{\alpha})Y_R$.

C. List of Resource-Rich Developing Countries

According to the IMF (2012), the following 29 countries belong to the group of RRDCs: Angola, Bolivia, Cameroon, Chad, Democratic Republic of Congo, Republic of Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guyana, Indonesia, Iraq, the Lao People's Democratic Republic, Liberia, Mali, Mauritania, Mongolia, Niger, Nigeria, Papua New Guinea, Sudan, Syria, Timor-Leste, Turkmenistan, Uzbekistan, Viet Nam, Yemen, and Zambia.

The comparison group are the following other resource-rich countries that have reached at least upper middle-income status: Australia, Botswana, Brazil, Canada, Chile, Kuwait, Norway, Oman, Qatar, Saudi Arabia, and United Arab Emirates.

The following list includes the other least-developed countries that belong to the group of least-developed countries that are not at the same time classified as RRDCs: Afghanistan, Bangladesh, Benin, Burkina Faso, Cambodia, Central African Republic, Comoros, Gambia, Guinea-Bissau, Kiribati, Lesotho, Mali, Nepal, Rwanda, Senegal, Solomon Islands, Sierra Leone, São Tomé and Príncipe, Togo, Tuvalu, Tanzania, and Uganda.

