The Impact of Rising Oil Price on Remittances and Migrant Workers in a Small Developing Economy

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Abstract

The recent dramatic increase in the price of oil has coincided with a large increase in workers migrating to oil rich countries from developing economies and remitting large sums of money back home. This paper examines the consequences of an oil price shock for the migrant-remittance relationship, and the resulting impact on the developing country and the welfare of its constituents. The implications for the oil producing country are also briefly addressed. To reflect bureaucratic frictions, migration occurs gradually, introducing a sharp contrast between the short-run and long-run effects of an oil shock and the effects on the time path of the resulting remittances on the developing economy. To highlight the role of migration simulations are conducted for two scenarios: ongoing endogenous migration and a fixed quota of migrant workers. In both cases the welfare effects for domestic residents and migrants diverge quite markedly. To offset adverse effects of the oil shock, alternative tax policies are considered. Of these, while the fuel tax cut can help reduce the short-run severity of the shock, a reduction in labor income taxes is the most effective.

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1. Introduction

Following the decade of the 1990s with its generally stable oil prices, the price of oil increased drastically during the first decade of the 21st century, while also being subject to increased volatility. It jumped from roughly US$20 per barrel prior to 2000 to as high as US$120 per barrel around the time of the global financial crisis of 2007-08. After the crisis, the oil price remained above US$100 per barrel until late 2014, before sliding back to around US$60 per barrel by the end of the decade. But this level is still three times as high as in the 1990s (see Fig. 1.A).

Concurrently with this evolution of the price of oil, there was an equally dramatic increase in the number of migrant workers. Over the 20 year period, 2000-2020, the number of migrant workers worldwide grew from 173 million to 281 million, a growth of over 62%. During the same period the average worldwide ratio of remittances to GDP more than doubled from 0.37% to 0.79%. There is of course substantial variation in this ratio across different economies. But it is significant that for the three largest South Asian countries – Bangladesh, India, and Pakistan – the ratios in 2020 were 6.7%, 3.1%, and 8.7% respectively, clearly a significant portion of their respective financial resources.

A large share of the remittances being sent back to the South Asian countries is from migrant workers employed in the oil producing countries of the Middle East. Knowing this, the similarity between the time paths followed by the remittance-GDP ratio, the number of migrant workers, and the price of oil over that period is quite striking. Figs. 1.C and 1.D show the trends of remittances as a share of GDP for Bangladesh and Sri Lanka. The remittance-GDP ratio for Bangladesh hovered around 3.47% from the late 1980s to early 2000s. It then rose quickly to average 8.93% for about a decade, coinciding with the oil price surge, before declining to around 5.54%, generally tracking the trend of the oil price. The rapid rise in the amount of remittances up until the mid-2010s was driven mainly by the flock of migrant workers to the Middle East countries. This is true especially during the first of half of 2010s. According to World Bank's Global Bilateral Migration, the stock of Bangladeshi migrant workers jumped from about 1 million in 2010 to 3.2 million in 2013, after which it tended to taper off (Fig. 1.B).

Similar trends are observed for Sri Lanka. The remittance share of GDP rose rapidly from about 5% in the late 1980s to around 8% in the 2000s, peaking at 8.5% after the 2009 global recession. It then fell back sharply to about 6% in 2021. Data for Sri Lankan migrant workers show a similar pattern. As a share of population, their number rose drastically during the oil price surge, from 2% in 1990 peaking at 8.3% in 2010, before declining to 7.3% in 2017; (Lim, 2021).

The parallel time paths followed by the price of oil, migrant workers, and remittances illustrated in Fig. 1 raise the important question of an apparent linkage between them, or whether the relationship is just spurious, reflecting some common underlying worldwide trend. To address this issue we adapt a recent macro-dynamic model developed by Lim, Morshed, and Turnovsky (2023). This model sets out the relationship between two small open economies – a labor-importing, advanced economy and a labor-exporting, developing economy – to examine the interdependent flows between migrant workers and their remittances. Calibrating the system to reflect the key generic characteristics of two such economies, the paper demonstrates how different structural changes, and potential policy responses, impact the dynamics of the remittance-migrant worker relationship and their welfare consequences for the various constituent groups in the two economies. An important feature of this setup is to highlight the distinction between the decision to migrate (a decision at the extensive margin) vs. the migrants' decisions regarding their labor supply (a decision at the intensive margin) and how these decisions interact over time.

Clearly, given the major role played by oil production in the world economy and its asymmetric consequences for oil-producing and oil-importing economies, how it impacts the migrant-remittance relationship is important, particularly in light of the empirical evidence documenting the precipitous rise in the price of oil. Our analysis highlights how the introduction of migration produces a sharp contrast between the short-run and long-run effects of higher oil prices, set by the oil producing economy, on the developing economy. On impact, the higher oil price raises the wage of migrant workers, inducing them to increase their labor supply. The higher wage immediately attracts more migrant labor, similar to that observed empirically, reducing the migrant wage rate, and causing the growing number of migrant workers to reduce their individual labor supply. This has profound implications for the remittance to GDP ratio. In the short run, the higher migrant wage leads to a substantial increase in the ratio, but this tapers off over time, as the migrant wage rate and labor supply decline. In the long run, the increase in the ratio is sustained, but this is primarily because of the decline in output of the oil-importing nation.

While the welfare benefits of a higher oil price for the oil-producing country are clear-cut, the consequences for the constituents of the developing country are more conflicted. In the case of residents remaining in the home economy – "stayers" – the recession caused by the higher oil price reduces consumption (welfare reducing) although this is moderated by the increase in remittances, together with the increased leisure (welfare improving). Migrants, on the other hand, experience a slightly smaller reduction in consumption, but with higher wages, increase their labor and enjoy less leisure. On balance, for our benchmark calibration, individual migrants experience a slightly larger welfare loss than do stayers. To offset these adverse effects we compare cutting alternative tax rates. Of these, reducing the tax on labor income is the most effective. In fact, an appropriate cut in the tax on labor income can eliminate the welfare losses to stayers, while increasing the consumption of migrants, so that their individual welfare actually improves.

This paper is related to two distinct bodies of literature. The first pertains to the impact of remittances on various aspects of the recipient nation's economy. This is a burgeoning literature, and extensive references are provided by Lim et al. (2023). There it is noted that most studies treat remittances as exogenous, ignoring any potential link between remittances and the growth of migrant labor. The literature relating remittances and migrant workers is sparser, although it too has recently been growing; see e.g. Lundborg and Segerstrom (2002), Levine et al. (2010), Mandelman and Zlate (2012), Ikhenaode and Parello (2020), Lim et al. (2021, 2023). Using remittance and migrant stock data for 122 countries from 1990 to 2010, Lim and Morshed (2015), show that while an income shock does not induce existing migrants to send more remittances, labor migration does indeed lead to increased remittances, underscoring the need to analyze remittances and labor migration as jointly determined decisions.

The second major body of literature that is much older, relates to the potential and actual adverse effects of increases and fluctuations in oil price shocks on the world economy. The occurrence of the "oil crisis" in the 1970s first stimulated interest in this issue, generating an extensive literature studying the impact of higher oil prices on the economy. This early literature was almost entirely short run, dealing with issues such as "stagflation" and figuring appropriate policy responses; see e.g. Corden (1975), and Findlay and Rodriquez (1977).

By emphasizing the short run, most of the early literature ignored the consequences of oil shocks on capital accumulation and its longer run implications for economic growth. With the ongoing instability in the Middle East, the energy sector has continued to receive the attention of economists and policy makers. Much of the focus is on identifying the channels through which oil price shocks influence the performance of the economy, including its growth rate, though mostly from the standpoint of advanced nations; see Barsky and Kilian (2004).

The recent literature identifies a number of issues. First, is the observation that the effects of the more recent oil price shocks on real economic activity have been much milder than were those of the 1970s and 1980s, despite the fact that the earlier oil shocks were of approximately comparable relative magnitudes.[1] Most of this evidence is for developed economies, and in some cases output growth has barely been affected.[2] It attributes the reduced vulnerability of developed economies to oil price shocks to several factors, the most common being the reduced dependence on energy; see e.g. Dhawan and Jeske (2006), Nakov and Pescatori (2010) and the World Economic Outlook (2008). Other explanations include: better monetary policy (Nordhaus, 2007, Blanchard and Galí, 2000) and a decline in real wage rigidity (Blanchard and Galí, 2008).

Second, much of the more recent literature focuses on explaining the consequences of oil price shocks on the terms of trade and trade balance. For example, Backus and Crucini (2000) are concerned with explaining the variations in the terms of trade in a subset of OECD countries, and demonstrating how these can be largely attributed to oil supply shocks. In contrast, Bodenstein,

[1] This comparison is documented in detail by Blanchard and Galí (2008); see also Nordhaus (2007).

[2] See e.g. Nordhaus (2007), Blanchard and Galí (2008), OECD (2004). Using data for OECD countries over the period 1972-2001 Jiménez-Rodríguez and Sánchez (2005) find, that a 100% increase in the price of oil leads to an accumulated output loss ranging from 1% for Canada, to 2% for the Euro area, 3% for France, 4% for Italy, and 5% for USA and Germany.

Erceg, and Guerrieri (2011) analyze the effects of an oil price shock on the trade balance and real exchange rate of a large industrialized country like the US, Japan, or the Euro area, contrasting the responses under incomplete financial markets, with those under complete financial markets, assumed by Backus and Crucini. Methodologically, much of the more recent literature with its focus on the stochastic aspects, employs the DSGE setup; see e.g. Kim and Loungani (1992), Backus and Crucini (2000) and Bodenstein, Erceg and Guerrieri (2010) for various extensions of the seminal Kydland and Prescott (1982) framework.

In contrast to this literature, Schubert and Turnovsky (2011) analyze the impact of an oil price increase on a developing economy, where things are quite different. In contrast to the experience of advanced economies, OECD (2004) finds that in non-OECD countries oil intensities generally increased slightly up to the mid 1990s, before falling marginally. The World Economic Outlook (2008) reports that whereas energy consumption per unit of GDP has fallen by about 40% in advanced countries since the 1970s, emerging and especially developing countries are generally considerably more energy intensive. This evidence suggests that it is natural to expect an oil price shock to have more severe economic effects in a developing country than in a modern industrialized economy. To address these questions, they develop a neoclassical growth model of a small oil-importing developing economy, in which production depends upon labor, capital, as well as imported oil, the price of which is exogenous. This is in contrast to the present approach, where in Section 5 we show how the (changing) oil price reflects industrial policy of the oil producing economy, and thus is endogenously determined as part of the general equilibrium.

The remainder of the paper proceeds as follows. Section 2 sets out the analytical framework linking the oil-producing and oil-consuming economies, with Section 3 describing the macroeconomic equilibrium. Section 4 discusses the calibration, while Section 5 analyzes the impact of a reduction in the supply of oil and the resulting increase in its price. To clarify the role of migration, we also briefly address the polar case where the number of migrants is fixed, as well as some tax policy responses. Section 6 briefly assesses the sensitivity to variations in the significance of oil as a productive input of the developing economy, while Section 7 concludes. Finally, technical details describing the equilibrium and solution are relegated to the Appendix.

2. Analytical Framework

The analytical framework we employ comprises two small economies, one is an advanced oil-producing economy (e.g. Middle East Gulf States), also referred to as the “host” country. The oil-producing economy is treated as being small in the traded good and world financial markets, but it is sufficiently large in the oil market so that by changing its production mix it influences the equilibrium price of oil. The other is a developing economy (e.g. Bangladesh), also referred to as the “home” country, that requires oil as a productive input. It sends a fraction, $m(t)$, of its population as migrant workers to the advanced economy with the intent that they will remit some of their higher income to their families back home.

To focus on the endogeneity of migration and the consequent flow of remittances, Lim et al. (2023) simplified the production structure in the host country by allowing for only one traded good. By introducing oil as a second output, the enriched setup enables us to examine how changes in the productive structure in the host country, via their impact on the price of oil, influence migration and remittances, thereby impacting the macroeconomic conditions of the home country.

An important issue for subsequent calibration is to take account of the relative sizes of the two economies. This is because, although both Bangladesh and the Middle East Gulf States are “small” from a world perspective, the population of the former is approximately 3 times that of the latter. Also, Bangladeshi workers migrate to several advanced economies around the world, while Middle East countries employ migrant workers from many other developing economies. To adjust for these differences in the relative sizes of the home and host countries, we normalize the number of native workers in the host economy to be one, and the relative number of migrant workers to be θ. To account for the fact that firms in the host country hire some fraction from Bangladesh and the rest from elsewhere we write $\theta(m) \equiv \theta \cdot m = (\theta_1 + \theta_2)m$, where for simplicity, we normalize the size of each country supplying migrant workers to that of the home country.

Thus $\theta_1 \cdot m$ is the fraction of migrant workers in the host country *not* from the home country, while θ_2 adjusts for the relative size of host and home countries, and the fact that *m* is specified as a percentage of the home country population. Hence, the ratio of home migrant workers to total migrant workers in the host country is $\theta_2/(\theta_1+\theta_2)$, which the small host country treats as given.

2.1 Oil-producing Middle East country

The oil-producing Middle-East economy produces both an internationally traded consumption good, *H*, and oil, *Z*, using capital, K_h, that it rents from its households, labor supplied by native workers, N_h, and migrant labor, $\theta(m)N_m$. Since our focus is on the increase in the price of oil arising from the restructuring of the economy's productive activities, it is convenient to represent the productive capacity by the production possibility frontier (PPF):

$$T(H,Z) = X(K_h, N_h, \theta(m)N_m) \qquad T_H > 0, T_Z > 0, X_{K_h} > 0, X_{N_h} > 0, X_{\theta(m)N_m} > 0 \tag{1}$$

Eq. (1) thus describes the tradeoff between producing the consumption good, and oil, given the available aggregate inputs in $X(.)$, and is assumed to be homogeneous of degree one in the two outputs and three factors of production. As Samuelson (1966) initially showed, (1) in general is associated with joint production across sectors, although the specific nature of the jointness-in-production is not of particular concern here.[3]

We assume that the firm in the host economy chooses H, Z, K_h, N_h, N_m to maximize profit:

$$\Pi_h \equiv H + pZ - \rho_h K_h - w_h N_h - w_m \theta(m) N_m \tag{2}$$

subject to the technology, (1), where *p* is the price of oil, ρ_h is the return to capital, w_h is the native wage, and w_m is the migrant wage, all expressed in terms of units of the traded consumption good which serves as numeraire. The resulting optimality conditions are

$$\frac{T_Z(H,Z)}{T_H(H,Z)} = p \tag{3a}$$

[3]As Samuelson shows, the usual assumption of non-joint production imposes restrictions on the rank of various matrices related to the Hessian of the PPF. Further discussion of this issue is provided by Hirota and Kuga (1971) and Burmeister and Turnovsky (1971).

$$\frac{X_{K_h}(K_h, N_h, \theta(m)N_m)}{T_H(H,Z)} = \rho_h \tag{3b}$$

$$\frac{X_{N_h}(K_h, N_h, \theta(m)N_m)}{T_H(H,Z)} = w_h \tag{3c}$$

$$\frac{X_{\theta(m)N_m}(K_h, N_h, \theta(m)N_m)}{T_H(H,Z)} = w_m \tag{3d}$$

We assume that the price of the traded good is set exogenously at unity, while the price of oil, p, is endogenously determined in the world oil market, which the oil producing economy is large enough to influence. Aggregate output (GDP), Y_h, expressed in terms of the traded good is:

$$Y_h = pZ + H \tag{4}$$

In our simulations, we shall employ the functional form:

$$\left[\nu H^2 + (1-\nu)Z^2\right]^{1/2} = A_h\left[\alpha_k K_h^{\phi} + \left(1-\alpha_k\right)\left[\alpha_n N_h^{\xi} + \left(1-\alpha_n\right)\left(\theta(m)N_m\right)^{\xi}\right]^{\frac{\phi}{\xi}}\right]^{\frac{1}{\phi}} \tag{5a}$$

which asserts that the tradeoff between the production of the traded consumption good and oil is constrained by the aggregate resource endowment function, assumed to be of a nested CES form. From (5a), we see that the slope of the PPF is:

$$\frac{dH}{dZ} = -\left(\frac{1-\nu}{\nu}\right)\frac{Z}{H} < 0, \;\; \frac{d^2H}{dZ^2} < 0 \tag{5b}$$

implying that it has the conventional concave shape (with respect to the origin), reflecting the standard assumption of increasing marginal rate of transformation between the two goods. The mechanism whereby the Middle East oil-producing economy influences the equilibrium oil price is through the choice of ν, which determines the allocation of its productive inputs between the two goods. Reducing ν shifts resources away from oil production and raises its relative price. However, since this is a structural decision, made only infrequently, it is not incorporated into the continuous optimization summarized in (3).

Resident households of the oil producing economy own the capital and invest an amount, I_h, to accumulate additional capital that they rent to firms. But converting the new output acquired into capital incurs an adjustment cost, assumed to be of the standard form:

$$\Phi_h\left(I_h, K_h\right) = I_h\left(1 + \frac{\chi_h I_h}{2K_h}\right) \tag{6}$$

Each household in the oil-producing country is also endowed with a unit of time that it allocates between leisure, L_h, and work, N_h. Thus, native labor supply is subject to the constraint

$$N_h = 1 - L_h \tag{7}$$

Host country households also choose consumption, C_h, and leisure, (L_h, to maximize the concave utility function

$$V = \int_0^\infty V\left(C_h, L_h\right) e^{-\beta t} dt \tag{8a}$$

where β is the rate of time preference, subject to their accumulation of foreign debt and capital:

$$\dot{B}_h = r_h B_h + C_h + \Phi_h\left(I_h, K_h\right) - \rho_h K_h - w_h N_h \tag{8b}$$

$$\dot{K}_h = I_h - \delta_h K_h \tag{8c}$$

where r_h denotes borrowing costs faced by host residents, B_h is their holding of international debt, and δ_h is the depreciation rate of capital.

Due to financial frictions, the borrowing cost is an increasing and convex function, $\Psi(B_h/Y_h)$, of the nation's aggregate debt-output ratio (B_h/Y_h), as a measure of its ability to service its debt. Letting r^* denote the exogenous real world interest rate, the cost of borrowing is[4]

$$r_h\left(B_h, Y_h\right) = r^* + \Psi\left(\frac{B_h}{Y_h}\right); \quad \Psi(0) = 0,\ \Psi' > 0,\ \Psi'' > 0 \tag{9}$$

In making its decisions, the individual household cannot influence the economy's aggregate debt-output ratio and thus takes the borrowing cost as given.

Optimizing (8a) subject to (7), (8b) and (8c), with respect to C_h, L_h, B_h, I_h, K_h yields:

[4] Foreign borrowing constraints of the form (9) have a long tradition in international finance and provide a convenient way of closing the "small economy model"; see Turnovsky (1997). They were first introduced by Bardhan (1967) who expressed the borrowing premium in terms of absolute level of debt. Many variants, based on various forms of normalization of the debt level, have been employed (see Finkelstein Shapiro and Mandelman, 2016; Bahadir et al., 2018). Empirical evidence supporting functions of the form (9) is provided by Edwards (1984) and more recently by Chung and Turnovsky (2010).

$$V_{C_h}\left(C_h, L_h\right) = \pi \tag{10a}$$

$$V_{L_h}\left(C_h, L_h\right) = \pi w_h \tag{10b}$$

$$\beta - \frac{\dot{\pi}}{\pi} = r_h \tag{10c}$$

$$\frac{I_h}{K_h} = \frac{q_h - 1}{\chi_h} \tag{10d}$$

$$\frac{\dot{q}_h}{q_h} + \frac{1}{q_h}\left[\rho_h + \frac{\left(q_h - 1\right)^2}{2\chi_h}\right] - \delta_h = r_h \tag{10e}$$

together with its budget constraint, where π is the shadow value of household debt (traded bonds) and q_h denotes the shadow value of private capital, normalized by π.[5] In addition, the transversality conditions

$$\lim_{t\to\infty} \pi_h K_h e^{-\beta t} \equiv \lim_{t\to\infty} q_h \pi K_h e^{-\beta t} = \lim_{t\to\infty} \pi B_h e^{-\beta t} = 0 \tag{10f}$$

Eq. (10a) equates the marginal utility of the consumption good to the shadow price of wealth, while eq. (10b) implies that the marginal utility of leisure is equal to the utility-adjusted return to labor. Eq. (10c) is the Keynes-Ramsey consumption rule which equates the rate of return on consumption to the borrowing costs, while eq. (10d) describes investment in terms of the "Tobin *q*". Eq. (10e) equates the rate of return on physical capital inclusive of "capital gain", $\dot{q}_h/q_h$, and net of depreciation to the borrowing cost. The quadratic term, $(q_h - 1)^2$ in (10e) arises because increasing the capital stock reduces adjustment costs; see eq. (6).

2.1. Developing country (labor-exporting country)

We assume that there is a unit continuum of household members, a fraction, m, of whom are migrant workers, employed in the Middle East country, while the rest, $(1 - m)$, remain and work at home ("stayers"). The individual migrant worker earns $w_m N_m$ from his labor, of which C_m

[5] That is, if we let π_h denote the shadow (utility) value of capital, then $q_h \equiv \pi_h/\pi$. Written in this way, the normalized price becomes an "asset price" independent of utility units.

is spent on consumption. In addition, working abroad incurs fixed costs, x, for items such as registration, work permits and alike. The balance is sent back to the migrant's family in the home country, so that the aggregate remittances (R) received by the home economy is:[6]

$$R = m\left(w_m N_m - x - C_m\right) \tag{11}$$

2.1.1 The private sector

With a fraction m of the population migrating to work in the small Middle East economy, the production function of the developing economy is

$$Y = F\left(K, O, \left(1-m\right)N\right) \tag{12}$$

where Y is the developing economy's output, K is its capital stock, O is the oil used in production, and N is its labor supply. All oil is imported and subject to a tax of τ_z which is paid by domestic firms. The production function has the usual properties of positive, but diminishing, marginal products, and is homogeneous of degree one in the three productive factors, capital, oil, and labor. Thus, the corresponding profit maximizing conditions are

$$F_K\left(K, O, \left(1-m\right)N\right) = r_K \tag{13a}$$

$$F_O\left(K, O, \left(1-m\right)N\right) = p\left(1+\tau_z\right) \tag{13b}$$

$$F_{(1-m)N}\left(K, O, \left(1-m\right)N\right) = w \tag{13c}$$

where r_K is the real return on capital and w is the wage rate. By appropriate choice of units, the price of the traded output in the developing economy is assumed set at unity.

We further assume that, like the Middle East country, the household in the developing country can borrow in the international financial market, but in doing so it also faces increasing borrowing costs, specified by:

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[6] We should note that eq. (11) abstracts from remittances received by the home country from countries other than the designated host country. Since these are treated as exogenous to the two small economies, this omission does not affect our overall results; see Lim et al. (2021) for further discussion.

$$r\left(B,Y\right)=r^{*}+\Gamma\left(\frac{B}{Y}\right);\ \Gamma\left(0\right)=0,\ \Gamma'>0,\Gamma''>0 \tag{14}$$

where B is the country's stock of debt, r is the interest rate faced by the household in the developing country, and $\Gamma(B/Y)$ is the borrowing premium. As is the case for the Middle East country, the individual household cannot influence the interest rate it faces and so it takes $r(\cdot)$ as given.

The welfare of home country is represented by the weighted average of the utility of the stayers and migrants. This specification reflects the notion that they operate as a family unit, with migrant workers sending remittances back home. Also, many migrant workers are often only temporary guest workers, who migrate to work on contracts, while maintaining strong family ties, further justifying the maximization of their joint utility.[7] Thus, the household utility function is[8]

$$W=\int_{0}^{\infty}\left[\left(1-m\right)U\left(C,L\right)+mM\left(C_{m},L_{m}\right)\right]e^{-\beta t}dt \tag{15}$$

where $U(C, L)$ and $M(C_m, L_m)$ are the respective utility of stayers and migrants obtained by consuming the traded good, C, and enjoying L. Both utility functions follow the standard assumptions of concavity, with positive and diminishing marginal utility.

Domestic residents and migrant members of the household are both endowed with one unit of time that they allocate between work and leisure in accordance with the constraints:

$$N+L=1 \tag{16a}$$

$$N_{m}+L_{m}=1 \tag{16b}$$

In addition, they accumulate capital subject to adjustment costs, analogous to those characterizing the host country, namely

$$\Phi\left(I,K\right)=I\left(1+\frac{\chi I}{2K}\right) \tag{16c}$$

[7] We focus on temporary migrants. This is because most of the migrants to the Middle Eastern economies are temporary as there is virtually no pathway to citizenship in these countries even for skilled immigrants.

[8] The approach we are adopting of evaluating welfare in terms of joint household utility is consistent with studies, in which migrant workers send remittances back to their families; see e.g. Lucas and Stark (1985), Hoddinott (1994), Ilahi and Jafarey (1999), and more recently Murard (2016), and Ivlevs, Nikolova, and Graham (2019) for examples that embody this jointness of welfare in varying ways. This contrasts with an alternative approach, more applicable to skilled migrants (like scientists and academics), who evaluate their decision to migrate in terms of their own personal career benefits and individual welfare gains; see e.g. Ehrlich and Kim (2015).

In maximizing utility, the household in the developing economy is also subject to the financial constraint, (17a), together with the constraints (17b) and (17c), describing the gradual evolution of migration, $\varpi(t)$, and capital accumulation, $\dot{K}(t)$:

$$\begin{aligned}\dot{B} = rB + \Phi\left(I, K\right) - \left(1-\tau_k\right) r_K K - m\left[w_m N_m - C_m - x\right] \\ -\left(1-m\right)\left[(1-\tau_w)wN - (1+\tau_c)C\right] + a\varpi + \frac{h}{2}\varpi^2 + T\end{aligned} \tag{17a}$$

$$\dot{m} = \varpi \tag{17b}$$

$$\dot{K} = I - \delta K \tag{17c}$$

where capital depreciates at a constant rate δ. T represents lump-sum taxes, while τ_k, τ_w, and τ_c, are distortionary taxes imposed on domestic capital income, labor income, and consumption, respectively.[9] The right hand side of (17a) identifies the net increase in debt, $\dot{B}$, incurred by the home household. This includes the interest owing on its outstanding debt, expenditures associated with investment inclusive of installation costs, costs associated with migration, ($a\varpi + (h/2)\varpi^2$), and lump sum taxes and is offset by remittances received and the net after-tax saving of stayers.

A critical feature of the analysis is the nature of the costs associated with migration. In this regard we follow Lim et al. (2023), and specify that the household faces quadratic costs of migration. This reflects the reality that the process of migrating is both costly and takes time. These costs are borne collectively by the household, and are reflected in a and h. The parameter a may be interpreted as reflecting "fixed costs" arising from the initial application and paper work associated with migration, as well as quotas imposed by the host country, and affects the long-run stock of migrant workers. In contrast, h influences only the speed with which migration actually proceeds during the transition and may be associated with "variable costs".

The limiting case $h \to \infty$ implies that the number of migrant workers remains fixed at its initial value that can be interpreted as being strictly imposed by the host country. This too is both important and relevant, since historically many countries that employ substantial quantities of

[9] For simplicity we abstract from government debt, the role of which is adequately proxied by lump-sum taxes.

migrant workers have adopted strict quotas. These have included Saudi Arabia, which has required non-Saudi migrant workers to have a local sponsor who secures a work permit and residence card under what is known as the *Kafala* system.[10]

While we treat ongoing migration as the benchmark case, we shall also briefly consider the case of where the stock of migrant workers remains fixed. We find this comparison to be enlightening in revealing the differential impacts these two scenarios imply for the developing economy. In particular, the tradeoff between the number of migrant workers and their individual labor supply is quite striking.

Choosing, $C, L, C_m, L_m, B, I, K, \varpi$, and m to maximize utility, (15), subject to the labor allocation conditions for stayers, (16a) and migrant workers (16b), the consolidated budget constraint (17a), the evolution of migration (17b), and capital accumulation (17c) yields the optimality conditions:

$$U_C\left(C,L\right)=\lambda\left(1+\tau_c\right) \tag{18a}$$

$$U_L\left(C,L\right)=\lambda\left(1-\tau_w\right)w \tag{18b}$$

$$M_{C_m}\left(C_m,L_m\right)=\lambda \tag{18c}$$

$$M_{L_m}\left(C_m,L_m\right)=\lambda w_m \tag{18d}$$

$$\beta-\frac{\dot{\lambda}}{\lambda}=r \tag{18e}$$

$$\frac{I}{K}=\frac{q-1}{\chi} \tag{18f}$$

$$\frac{\dot{q}}{q}+\frac{1}{q}\left[\left(1-\tau_k\right)r_K+\frac{\left(q-1\right)^2}{2\chi}\right]-\delta=r \qquad \text{(18g}$$

$$\varpi=\frac{s-a}{h} \tag{18h}$$

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[10] Further discussion of the *Kafala* system is provided in the Appendix to Lim et al. (2023), where we note how it is in the process of becoming more relaxed.

$$\frac{M\left(C_m, L_m\right)-U\left(C, L\right)}{s\lambda}+\frac{1}{s}\left(w_m N_m - x - C_m\right) \; -\frac{1}{s}\left[\left(1-\tau_w\right)wN-\left(1+\tau_c\right)C\right]=r-\frac{\dot{s}}{s} \qquad (18i)$$

where λ, is the shadow value of wealth (expressed in terms of utility), q is the shadow value of capital, normalized by λ, and s is the shadow value of migration (expressed in units of wealth).

Eqs. (18a) to (18g) are analogous to (10a) – (10e), the only difference being that (18c) and (18d) apply to migrants, with the rest applying to stayers.[11] The remaining two equations, (18h) and (18i), apply only to migrants. The former states that the rate of migration is proportional to the difference between the shadow value of being a migrant and the base costs, at a speed that varies inversely with the marginal costs. The latter treats migration as an asset. It asserts that the net rate of return to migration comprises the difference in utility, plus the difference in the net income between migrants and stayers per unit of cost, and given by the left hand side, must equal the opportunity cost of investing, taking into account the "capital gains" of migrating, and given by the right hand side. Finally, (18j), ensures that the household is intertemporally solvent

$$\lim_{t\to\infty} q\lambda K e^{-\beta t} = \lim_{t\to\infty} s\lambda m e^{-\beta t} = \lim_{t\to\infty} \lambda B e^{-\beta t} = 0 \qquad (18j)$$

2.1.2 The government

The government of the developing country is assumed to set its expenditure policy so as to claim a fixed share, g, ($0<g<1$), of output, so that government spending, G, is specified by $G = gY$. We also assume that the government maintains a continuously balanced budget, so that the government budget constraint is

$$G = gY = \left(1-m\right)\left(\tau_c C + \tau_w wN\right) + \tau_z pO + \tau_k r_K K + T \qquad (19)$$

This implies that, if τ_k, τ_w, τ_c, and τ_z are all fixed, as we shall assume, then along the transitional path, as economic activity and the tax/expenditure base is changing, the rate of lump-sum taxes (transfers), T, must be continuously adjusted to maintain budget balance. For simplicity, we assume that the utility benefits government consumption yields to households are additively

[11] For simplicity we assume that all agents in the two economies have the same rate of time discount.

separable. It therefore has no impact on consumer behavior and without loss of generality its utility has been set to zero in eq. (15); the primary reason for introducing it is to facilitate the calibration.

3. Macroeconomic equilibrium

The Middle East economy exports oil to many countries throughout the world, in addition to the small developing home economy. To close the system we assume that the market for Middle East oil clears. To do so, we introduce the demand from the rest of the world, which follows a constant elasticity function, $J_Z = A_J p^{-\varphi}$.[12] Market clearance for the Middle East oil market is

$$Z = O + J_Z \tag{20a}$$

which, recalling (3a), can be expressed as

$$Z = O + A_J p^{-\varphi} = O + A_J \left[\frac{T_Z(H,Z)}{T_H(H,Z)} \right]^{-\varphi} \tag{20b}$$

Together with the optimality conditions of the two economies, eqs. (10a – 10e) and eqs. (18a – 18i), and their respective resource constraints, we can derive the general macroeconomic equilibrium. First, using (3c) and (7) we can solve (1), (10a), (10b), and (20b) for the short-run consumption, labor supply, and outputs in the host economy:

$$C_h = C_h\left(\pi, K_h, m, N_m, O\right) \tag{21a}$$

$$N_h = N_h\left(\pi, K_h, m, N_m, O\right) \tag{21b}$$

$$H = H\left(\pi, K_h, m, N_m, O\right) \tag{21c}$$

$$Z = Z\left(\pi, K_h, m, N_m, O\right) \tag{21d}$$

Then, using (3a), (3d), (13c), (16a), and (16b), we can solve (13b), (18a), (18b), (18c), and (18d) for the short-run consumption labor supply and oil usage in the home economy:

$$C = C\left(\pi, K_h, N_h, H, Z, m, \lambda, K\right) \tag{22a}$$

[12] Exogenous demand shocks such as China's accession to the WTO can easily be incorporated into the model by varying the size of A_J.

$$N = N\left(\pi, K_h, N_h, H, Z, m, \lambda, K\right) \tag{22b}$$

$$C_m = C_m\left(\pi, K_h, N_h, H, Z, m, \lambda, K\right) \tag{22c}$$

$$N_m = N_m\left(\pi, K_h, N_h, H, Z, m, \lambda, K\right) \tag{22d}$$

$$O = O\left(\pi, K_h, N_h, H, Z, m, \lambda, K\right) \tag{22e}$$

Writing the system in this way highlights the two key channels linking the two economies. Production in the oil-producing Middle East country depends in part on the number of migrant workers and their labor, while production in the developing economy requires oil imported from the Middle East to use as an input. Combining the two sets of equations (21a – 21d) and (22a – 22e), we can derive C_h, N_h, H, Z, C, N, C_m, N_m, and O as functions of the dynamically evolving variables π, K_h, m, λ, K, which summarize the complete autonomous dynamic system linking the home and the host economies. This equilibrium dynamic system, (A.1) and (A.2), and its linear approximation, (A.3), around the steady state form the basis for our numerical simulations and are reported in the Appendix. There it is seen to be an autonomous system of 10 dynamic variables in (i) the capital stocks in the two economies, K_h , K; (ii) the stocks of debt in the two economies, B_h, B; (iii) the stock of migrant workers, m; and (iv) the corresponding shadow values, q_h, q, π, λ, and s. Of these ten dynamically evolving variables, the five stock variables are constrained to evolve gradually from their given initial conditions, while the shadow values are free to respond instantaneously as new information becomes available.

In general, these equations are routine, but one critical equation obtained by combining (17b) and (18h) is worth highlighting:

$$\dot{m}(t) = \frac{s(t) - a}{h} \tag{23}$$

This equation is the key relationship describing how the migration decision at each instant of time is driven by the difference between the shadow value of migrating at that time, $s(t)$, and the fixed cost of migrating, a, with the speed of migration varying inversely with the marginal cost, h. This relationship will be recognized as being analogous to the corresponding relationship in the seminal Harris and Todaro (1970) migration model, though there is a difference. That paper postulated the migration of labor between rural and urban areas to be proportional to the wage differential between the two sectors. Being based on intertemporal optimization, the current migrant wage rate is replaced by the shadow value of migration. This reflects the discounted value of the future benefits from migration, embodied in $s(t)$ which in principle can be obtained by solving (18i).

3.1 Steady state

In the long run, both economies converge to a steady state in which all variables are constant through time. The steady-state values, denoted by "~", are set out as eqs. (B.1) and (B.2) in Appendix B. Together, they comprise 22 equations that jointly determine 8 steady-state values, $\tilde{C}_h, \tilde{N}_h, \tilde{L}_h, \tilde{K}_h, \tilde{B}_h, \tilde{H}, \tilde{Z}, \tilde{q}_h$, pertaining to the host economy, and 13 steady-state values, $\tilde{C}, \tilde{C}_m, \tilde{N}, \tilde{N}_m \tilde{L}, \tilde{L}_m, \tilde{K}, \tilde{B}, \tilde{O}, \tilde{R}, \tilde{m}, \tilde{q}, \tilde{s}$, for the home economy, plus the equilibrium price of oil, $\tilde{p}$.

They incorporate the sources of long-run inter-dependence between the two economies.

4. Calibration

To gain further insights, we calibrate the model using data characteristic of Middle East oil producing economies and labor-exporting, developing economies. To do so, we first specify functional forms and choose appropriate parameter values.

4.1 Functional forms

The developing country's utility functions for stayers' and migrants' preferences are:

$$U(C,L) = \frac{1}{\gamma}\left(CL^{\sigma}\right)^{\gamma}; \quad M(C_m, L_m) = \frac{1}{\gamma}\left(C_m L_m{}^{\sigma_m}\right)^{\gamma} \tag{24a}$$

where σ, σ_m represents the relative importance of leisure in their respective utility functions, and $1/(1-\gamma)$ is the intertemporal elasticity of substitution.

The production function in the developing economy is of the standard CES form

$$Y = A\left[\vartheta_k K^{\zeta} + \vartheta_o O^{\zeta} + \left(1-\vartheta_k - \vartheta_o\right)\left[\left(1-m\right)N\right]^{\zeta}\right]^{\frac{1}{\zeta}} \tag{24b}$$

where $-\infty < \zeta < 1; 1/(1-\zeta)$ is the common CES across all inputs, $0 < \vartheta_k, \vartheta_o < 1$ are the relative intensities of capital and oil used in the production, and *A* is the level of technology (TFP) of the developing country. The interest rate faced by the domestic country's borrowers is[13]

$$r = r^* + e^{b(B/Y)} - 1 \tag{24c}$$

where b is the rate at which the borrowing premium increases with the debt to GDP ratio.

The oil producing country's utility function is analogous

$$V(C_h, L_h) = \frac{1}{\gamma}\left(C_h L_h^{\ \sigma}\right)^{\gamma} \tag{25a}$$

while its production capacity is summarized by the PPF, (4a)

$$\left[\nu H^2 + (1-\nu)Z^2\right]^{1/2} = A_h\left[\alpha_k K_h^{\phi} + (1-\alpha_k)\left[\alpha_n N_h^{\xi} + (1-\alpha_n)\left(\theta(m)N_m\right)^{\xi}\right]^{\frac{\phi}{\xi}}\right]^{\frac{1}{\phi}} \tag{25b}$$

The overall productive capacity of the economy that can be split between producing oil and the final consumption good is expressed as a two-stage, three-input nested CES function. In the first stage, native and migrant workers combine via a CES aggregator to yield total labor, which is then combined with capital to produce the traded good and oil; $-\infty < \phi, \xi < 1$; $1/(1-\phi)$ and $1/(1-\xi)$ are the CES between capital stock and labor, and between native and migrant workers, respectively. In addition, $0 < \alpha_k, \alpha_n < 1$ are the relative intensities of capital and native labor (in the nest), respectively, while A_h is the TFP of the host country. The borrowing cost faced by the Middle East country's residents is specified analogously by

$$r_h = r^* + e^{d(B_h/Y_h)} - 1 \tag{25c}$$

where $d < b$ implies that being wealthier, Middle East borrowers face a lower premium.

4.2 Welfare measures

Having established how an increase in the oil price impacts economic decision making in the home and host economies, including decisions pertaining to remittances and migration, an

[13] This functional form is widely adopted. Increasing *b* offers a convenient and flexible representation of increasing borrowing costs for numerical simulations.

overriding issue is the effect on the welfare of the different constituents, namely the stayers and migrant workers of the home economy and the citizens of the host economy. To calculate the change in welfare of these constituent groups we use the conventional Hicksian measure of equivalent variation. Details of the calculation of the various measures are provided in Appendix A.3 of Lim et al. (2023). We assume that the economy is initially in steady-state equilibrium and begin by considering the impact on the welfare of the typical individual, in the home economy, and then aggregate over the groups of stayers and migrant workers, as well as residents of the host economy. We provide two sets of welfare measures. The first measures intertemporal welfare, which takes account of the gains or losses along the transitional path as the economies converge to the new steady state. The other measure is the welfare gain across the steady states for each individual, each group, and each country. Both welfare measures are of interest. The steady-state measure is more appropriate for comparing the long-run welfare of two economies experiencing the specified structural differences, while the intertemporal welfare measure is more relevant for a single economy as it transitions following some structural change.

In the case of the home economy, the aggregation is more complicated by the fact that in the process of migration the relative sizes of the groups of stayers and migrant workers are continuously changing. Taking this into account we report the following welfare measures: (i) $\Delta\omega_d$, the change in welfare of an individual stayer who never migrates; (ii) $\Delta\omega_m$ the change in the welfare of an individual who migrates at time 0. Corresponding to these, we obtain the aggregate welfare changes for each group, $\Delta W_d, \Delta W_m$. Note that while an individual's welfare may increase, changes in the relative size due to migration may cause the overall group's welfare to decline (or vice versa). The overall average change in the intertemporal welfare of the home economy is a weighted average of the welfare of the two groups. In the case of the host economy, with no migration $\Delta\omega_h$ is an unambiguous measure of the change in the welfare of an individual resident as well as in the overall average welfare.

4.3 Parameter values and benchmark steady-state equilibrium

Table 1 reports the parameter values used to obtain the benchmark steady-state equilibrium summarized in Table 2. These parameters draw heavily on, and are generally consistent with, the range of empirical evidence as indicated in Table 2. We identify the "host" country as comprising the 5 Middle East countries, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, which except for their position in the international oil market can be collectively viewed as small. Also, while we focus on Bangladesh as being the small "home" country, we recognize that the Middle East import larger numbers of migrant workers from other countries, including other South Asian countries, while almost 50% of Bangladeshi migrant workers are employed elsewhere.[14] Furthermore, we acknowledge that the individual oil importing countries vary structurally and with respect to their usage and sources of oil, as well as the destination of their migrant workers. This makes it impractical to calibrate the model by targeting specific moments to a specific country. Rather, our objective is to use the available information to characterize an initial plausible equilibrium for a typical oil-dependent developing economy.

For simplicity, (and in the absence of any contrary evidence) we assume that the residents of the home and host countries share many common taste parameters, including $\gamma, \sigma,$ and β. The choice of $\gamma = -1.5$ implies an intertemporal elasticity of substitution of 0.4, which is well within the consensus range of estimates provided by the extensive meta-study Havranek et al. (2015). The exponent on leisure in the utility functions $(\sigma = 1.75)$ yields consistent labor supplies for the two economies. The resulting equilibrium time allocation of native workers in the host country, $\tilde{N}_h = 0.3003$, is compatible with the time allocation typically assumed for advanced economies. The time allocation of workers in the home country, $\tilde{N} = 0.2494$, is consistent with the time use survey for Bangladesh (see Bangladesh Bureau of Statistics, 2013; Narasimhan & Pandey, 1999). These parameters also yield plausible consumption-output ratios for the two

[14] Most of the migrants from Bangladesh to the Middle East are unskilled labor. According to the Bangladesh Household Remittance Survey, 2009, only 12% of the migrants completed 10th grade level of education. Most of the skilled workers from South Asia migrate to the US, UK, or Europe.

economies, $(\tilde{C}_h/\tilde{Y}_h = 0.6577, \tilde{C}/\tilde{Y} = 0.7477)$.

Setting $\sigma_m = 2.5$ in the migrants' utility function yields migrant labor supply $\tilde{N}_m = 0.4344$, consistent with the evidence that migrants in the Gulf worked more than 10 hours a day (Rajan et al. 2015). [15] This also implies that the consumption-income ratio for migrant workers is lower (around 0.45), a natural consequence of their commitment to remit some of their income back to the home economy. We set the migration/remittance cost *x* = 0.15, which is equivalent to 9.25% of the migrants' wage rate. [16]

Setting the migration cost at *a* = 5 implies that in the initial steady state 3.51% of the home population are employed as migrant workers in the host country. Choosing $\theta_2 = 3$, to account for the relative size of the home and host economies, together with $\theta_1 = 14$ implies that the total ratio of migrant workers to native workers in the host country is around 60%, of which around 11% are from the home country, and a corresponding remittance-to-GDP ratio *R/Y* = 4.14%. Together with the time migrant and native workers allocate to work ($\tilde{N}_m = 0.4698$ and $\tilde{N}_h = 0.3003$) this implies that around 48% of total labor is supplied by migrant workers, These shares are typical of the South Asian presence in the Middle East economies; e.g., the migrant stock of Bangladesh in the UAE's population is about 11% in 2017 (United Nations, 2017). [17] Furthermore, these figures are also broadly consistent with the anecdotal fact that approximately 5% of Bangladeshis are migrant workers, with the recent total R/Y ratio averaging around 5.5%, but of whom only around 50-55% work in the identified set of Middle East countries.[18]

[15] Note N_m for migrant workers is highly sensitive to σ_m. Setting $\sigma_m = 2.5$ is motivated by the desire to target an equilibrium value for N_m that is closer to the empirical evidence cited by Rajan et al. (2015).

[16] Evidence on the fraction of their earnings migrant workers remit home is sparse. The UN Department of Economic and Social Affairs' News on Remittances suggests anecdotally that it is around 15%. Yang (2011) indicates that it varies extensively across countries, exceeding well over 30% in many cases, but no figure for Bangladesh is provided. Setting x = 0.15 implies that Bangladeshis remit about 30% of their gross income. While this may seem high, we should recall that we assume (as has been the case) that the host country does not impose income taxes. If, for example, the income earned by migrant workers in the host country were taxed at say 15%, the fraction of their gross income remitted would drop to around 15%.

[17] In 2017, the share of international migrant workers ranged from 25% in Saudi Arabia to 77% in United Arab Emirates and the share of migrant workers from Bangladesh to Saudi Arabia and UAE was 10% and 13%, respectively (United Nations, 2017).

[18] There is substantial year-to-year variation in countries' (including Bangladesh) *R/Y* ratio; see Fig 1.

The common rate of time preference, β , is set at 5%, and with the world interest rate, r^*, at 3.5%, both economies are net debtors in the long-run equilibrium. In either case, the long-run debt-GDP ratio is determined by the borrowing premium coefficient. Setting $b = 0.05$, the debt-GDP ratio for the home country (*B/Y*) is 30%, which is close to the recent Bangladesh experience. The recent debt-GDP ratios for the 5 Middle East countries vary extensively, between around 30% for Saudi Arabia to 150% for Qatar. Setting $d = 0.02$, for the wealthy host country, as a reflection of its less risky nature, implies B_h / Y_h = 74%. But we emphasize that our results are robust with respect to these two parameters.[19]

Setting $\zeta = -0.5$ in the production function of the domestic economy yields an elasticity of substitution between capital and labor (CES) equal to 0.67, consistent with estimates characterizing developing countries.[20] The relative capital intensity is set at $\vartheta_k = 0.25$ to obtain a capital-output ratio of 1.489, consistent with the data for Bangladesh that averaged about 2.1, and ranged between 1.23 and 3.3 between 1990 and 2014. The relative oil intensity is set at $\vartheta_o = 0.04$ to obtain the share of oil utilization of 7.9% consistent with the energy use (kg of oil equivalent) for \$100 GDP for a developing economy.[21]

For the Middle East country's aggregate production technology, the choice of $\phi = 0.04$ yields an CES equal to 1.04, which is close to the Duffy-Papageorgiou (2000) estimate for wealthier countries. An important element concerns the nature of the substitutability/complementarity relationship between migrant and native labor. Setting $\xi = -1$ implies an elasticity of substitution between migrant and native labor equal to 0.5, implying that they are complements, which is typical of the characterization of low-skilled migrant workers and appropriate in this context.[22] The relative capital intensity is set at $\alpha_k = 0.36$ implying a capital-

[19] This can be seen directly from (24c) in steady-state when the relationship reduces to $\beta - r^* = e^{d(B_h/Y_h)} - 1$.

[20] Most estimates of the CES for developing economies like Bangladesh are for industries and estimates vary widely. One of the few exceptions is the estimate for the aggregate manufacturing sector of 0.66 obtained by Rahman (1973).

[21] This is discussed further in Schubert and Turnovsky (2011) who vary the relative oil intensity in production between 0.02 and 0.06. Sensitivity analysis with regard to this parameter is conducted in Section 6.

[22] The issue of substitutability and complementarity between native labor and migrant workers has received considerable attention in the literature. Differences in the skill levels of migrant labor and native labor turn out to be crucial in determining whether they are substitutes or complements. Earlier authors, who focused on the production

output ratio of 3.85, which is consistent with the data for the Middle East countries.[23] Finally, the relative native labor intensity to migrant workers is set at $\alpha_n = 0.83$.

The key parameter characterizing production in the oil producing economy is v, which determines the relative mix of the two goods – the traded consumption good vs oil – the economy produces. With the choice for the parameters of the net oil demand from the rest of the world ($A_J = 1.3$, $\varphi = 1.25$), setting $v = 0.65$ yields the oil production share of GDP in the Middle Eastern country $\tilde{p}\tilde{Z}/\tilde{Y}_h = 0.3636$, which is consistent with the average oil production as a share of GDP in the Middle East. At the same time, we find $\tilde{O}/\tilde{Z}$ is approximately 1.1% reflecting the reality that only a small fraction of the Middle East oil production is exported to Bangladesh.

The depreciation rates of capital in both economies are $\delta_h = \delta = 0.05$, while the levels of technology (TFP) of the developing economy and that of the Middle East are $A = 1$ and $A_h = 2$, respectively. This yields the ratios of GDP between the Middle East and developing country to be about 18, which is within the broad range of empirical estimates on this measure.[24] Given all these chosen parameters, the model produces the following initial equilibrium real wage rates: native real wage $\tilde{w}_h = 6.8958$, migrants' real wage $\tilde{w}_m = 1.6200$, and the real wage for the domestic economy $\tilde{w} = 0.6494$. The implied relative wage rates are $\tilde{w}_h/\tilde{w}_m = 4.26$ and $\tilde{w}_m/\tilde{w} = 2.5$. These relative wage rates reflect the situation in the Middle East where most South

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structure channel while allowing for no differences in skill difference, found native and immigrant labor to be substitutes (Grossman, 1982). Autor, Katz, and Kearny (2008) find that college-educated native labor and non-college-educated migrants are complements, and that an increase in the supply of non-college-educated immigrants raises the wage of the college-educated native. Ottaviano and Peri (2012) show that once the skill differences are taken into account, immigration in the USA between 1990-2006 raises the native wage rate. Peri and Sparber (2009) show that in response to an increase in immigration, native workers change jobs and locations, which enhances the complementarity of native and immigrant labor. Peri (2016) also suggests that immigrants generate productive externalities, even via agglomeration externalities. Using data from Saudi Arabia and Kuwait, Erumban and Al-Mejren (2024) suggest that there exists a more complementary relationship between natives and immigrant labor.

[23] Between 1990 and 2014, the capital-output ratio for Saudi Arabia averaged around 3.2 and for UAE around 3.5.

[24] While the per capita GDP in terms of PPP of Bangladesh has grown steadily over the last several decades, that of the Gulf countries has fluctuated substantially, causing extensive variations in the GDP ratios. Over the period 2011-2020, the ratio of the annual GDP of Saudi Arabia and the UAE, (the two largest countries of our Middle East group) to that of Bangladesh averaged 13.4 and 17.5 respectively, with corresponding standard deviations of 5.1 and 5.3. The mean of the GDP ratio of Qatar, the richest country, was 29.0 with a standard deviation 14.2; see https://data.worldbank.org/indicator/

Asian migrant workers are low-skilled, while the natives are high-skilled professionals. They are also consistent with the relative internal data for India, as reported by Rajan et al. (2015),

The domestic country's government consumption is set at 15% of output $(g = 0.15)$, close to the recent Bangladeshi ratio of 15.3%, as reported by the Ministry of Finance. The tax rates for capital income, consumption, and labor income are the tax rates for corporate income, value-added, and individual income, respectively. They are taken from KPMG Tax Rates Online.[25]

Finally, while we follow the usual procedure and calibrate the model based on long-run steady-state relationships, there are in fact three parameters that are irrelevant with respect to the steady state, but impact the transition, namely h, χ_h, χ. Information on these are sparse. Lim et al. (2023) justify $h = 25$ as generally consistent with respect to speed of migration experienced by Bangladeshi migrant workers. They also conduct some sensitivity analysis with regard to this parameter and find that the results are robust with regard to this parameter. Accordingly, we adopt $h = 25$ and also set $\chi_h = \chi = 0.85$, drawing upon the empirical estimates obtained by Finkelstein Shapiro and Mandelman (2016).

5. Reduction in supply of oil and increase in oil price

We now address the effect of an increase in the price of oil faced by the developing economy. We shall assume that this occurs by means of a change in the Middle East country's production structure, parameterized by reducing v from 0.65 to 0.40, whereby it redeploys its available productive resources away from oil production to more of the traded good. To highlight the role of migration, and the tradeoffs between the migrants' "extensive" and "intensive" marginal employment decisions we contrast the cases where ongoing migration occurs, with the extreme case where the number of migrant workers is fixed via a quota system imposed by the host country.

The long-run consequences of the increase in the oil price for key economic variables for the two scenarios are provided in Panels (i) and (ii) of Table 3. Fig. 2 depicts the transitional

[25] These tax rates are typical of countries such as India and Pakistan that send many migrants to the Middle East. Income tax rates in UAE and other Middle East countries are zero. Lim et al. (2023) also discuss the role of taxes on remittances, which they note generated a lively debate; see Bhagwati and Wilson (1989). But since this is not particularly pertinent to the role of oil shocks being addressed here, there is no need to consider them.

paths of the key economic variables of the Middle East economy, the developing economy, and migrant workers responding to the shock under the two scenarios. Three alternative policy responses, directed at offsetting some of the adverse effects of the oil price increase on the home economy are also reported; see Panel (iii) and Fig. 3.

We should emphasize that parameterizing changes in the host country's production structure by varying the parameter v in the PPF, (25b), captures the essence of recent industrial policies in the oil-exporting countries. For example, to reduce their extreme dependence on oil, the UAE and Saudi Arabia have devised and started implementing policies emphasizing export diversification, making huge investments in non-oil sectors. In 2010 the UAE enacted Vision 2021, and has recently updated its policy stance toward further export diversification (Hana, 2017). Saudi Arabia has created and started implementing their own Vision 2030, where export diversification is the main economic goal (Habibi, 2019).

Moreover, our parameterization of reducing the weight, v, in the PPF from 0.65 to 0.4 matches remarkably closely the structural change implemented by Saudi Arabia. Comparing the benchmark with panel (i) in Table 3, we see that in the long run oil exports as a share of the host country's GDP are reduced from 36.4% to 25.2%, an 11.2 percentage points (p.p.) reduction. This is almost identical to the equivalent 12 p.p. reduction from 38.5% to 26.5% estimated to occur in Saudi Arabia between 2020 and 2030 under its Vision 2030 initiative. [26] Furthermore, the closeness of this match suggests that our approach of representing the production capacity by the PPF, (25b), is a convenient way of summarizing the economy's industrial structure.

5.1 Endogenous migration

Decreasing v from 0.65 to 0.4 immediately reduces the production of oil by about 30%, while traded output increases by around 46%, causing the relative price of oil to increase by around 33%. GDP, measured in units of traded output instantly expands by 27%, causing the real wage rate of native workers and migrants to increase by about 15% and 16%, respectively. With

[26] See Havrlant and Darandary (2021, Table 6).

the capital stock in the host country fixed instantaneously, and migration occurring only gradually, the increase in activity is met by immediate increases in both native labor supply, N_h, and the migrant workers' labor supply, N_m, which increase by about 2.6 p.p. and 3.8 p.p., respectively. The higher income and wage in the host country leads to an immediate increase in consumption by both native and migrant workers.[27]

In contrast, the higher oil price has an immediate adverse effect on the developing economy. Its utilization of oil drops by around 19%. With oil accounting for approximately 8% of its productive inputs, and with a negligible initial impact on domestic labor supply, GDP in the developing economy declines by around 2%. This in turn leads to a 4% reduction in the home country wage rate and an approximately equal reduction in stayers' consumption. The significant wage increase of migrant workers, coupled with the slight reduction in the income of the developing economy, induces them to substantially increase their remittances, with the R/Y ratio jumping up from 4.2% to nearly 7%. This pattern broadly reflects the experience of Bangladesh in the first years of the 21st century, as illustrated in Fig. 1.

However, these initial responses are soon reversed. This results from two effects. First, the increase in employment in the Middle East economy increases the productivity of capital, causing firms there to start accumulating more capital. This raises its overall productive capacity, enabling it to increase the production of both the traded good and oil, putting downward pressure on the price of oil, which in the short run declines by about 5% before more or less stabilizing.

In addition, the substantial increase in the wage rate of migrant workers encourages migration, which starts to increase rapidly ($\dot{m}(0) > 0$). From Fig 2.C(iii) we see that over the first 8 years following the increase in the price of oil the stock of migrant workers in the host country increases by 30%, similar to the observed pattern illustrated in Fig 1.C. But a consequence of this dramatic increase in migration is that the wage rate of migrant workers rapidly declines, as does the amount of labor each individual migrant provides. After several years, the migrant wage rate

[27] The result that the oil exporting country experiences an increase in GDP following the increase in the oil price is consistent with the empirical evidence of the period.

will have fallen slightly below its pre-oil shock equilibrium level, with migrant labor supply being slightly above. At this point the marginal benefits of further migration, reflected in *s*, have declined to slightly below the marginal migration costs *a*, *h*, causing some mild reverse migration and a general leveling off in the home economy. The net effect on the remittance to output ratio is that it will decline to an amount about 1 p.p. above its pre-shock level. With the consumption of migrant workers also declining to approximately their pre-shock level, this slight permanent increase in the R/Y ratio primarily reflects the permanent reduction in output and consumption of the developing economy due to the higher oil price. The fact that migrants increase remittances when their home economies experience adverse conditions is consistent with evidence provided by Yang (2008), Acosta et al. (2009), Chatterjee and Turnovsky (2018), and others.

Focusing on the welfare consequences of this increase in the price of oil, unsurprisingly, the Middle East economy benefits enormously. Its capital stock rises with the inflow of migrant workers, allowing the economy to permanently expand its production. The production shift also leads to a huge increase in consumption, and thus the welfare for its citizens. The aggregate welfare measured along the transition improves over 9%, and that measured as a change from the initial steady-state value improves by over 38%. The large difference between these two measures is due to the substantial decline in leisure which occurs primarily at the early stages of the transition, and which therefore weighs heavily in the intertemporal welfare calculation.

The consequences for the developing economy are more conflicted, with differential consequences for stayers and migrants. In the long run, the remittance-GDP ratio settles at 5.14%, 1 p.p. higher than its initial steady-state level. This reflects a combination of an increase in remittances together with a lower GDP. Domestic consumption declines by 3.5%, while the stayers' leisure increases by 0.33 p.p. As a result, comparing steady states, individual stayer's welfare is reduced by 2.76%, but the collective welfare of stayers declines by 3.40%, as more workers have migrated abroad.

In the new steady state, individual migrant consumption and leisure decrease by 2.18% and 0.32 p.p., respectively, implying that each individual experiences an overall steady-state welfare loss of 3.64%. With the number of individual migrants increasing substantially during the transition (around 18.2%), the collective welfare of the migrant group across steady states increases by about 13.9%. But the transition is also associated with substantial increases in migrant labor supply (decreases in leisure) that occur primarily during its early stages and impose welfare losses. Individuals who migrate at time 0 suffer an overall intertemporal welfare loss of 4.33%. Those migrating later in the transition supply less labor and suffer smaller welfare losses, but which collectively aggregate over time to 17.0%.

Thus, the increase in the oil price generated by the host country has adverse welfare consequences for the developing economy. From a steady-state perspective, individual stayers and migrants would both lose, the former by around 2.76%, the latter by 3.64%. As a group, due to their increase in numbers, migrants would gain relative to stayers, but with a net welfare loss to the home economy of 2.80%. But taking into account the consumption and leisure during the transition, the overall decline in the home economy's intertemporal welfare is reduced to 2.68%, due primarily to the increased leisure enjoyed by stayers during the transition.

5.2 Fixed migrant quota

Whether migration is ongoing or the number of migrant workers fixed by a quota has a relatively modest effect on the Middle East economy's changes in its production activities resulting from the structural change and the associated increase in the price of oil. This is evident from Figs. 2.A(i) – 2.A.(iv), where we see that the production of oil, the price of oil, the traded output, and the economy's GDP all track each other quite closely under the two scenarios. The short-run continued increase in production of both goods following the initial discrete response, remains as before, due to the accumulation of additional capital that is occurring and the enhanced productive capacity it yields.

But the absence of additional migration does have some impact on the oil producing economy, and this is due to the response of the existing migrant workers' labor supply (N_m). Without the inflow of additional migrant workers, the higher wage rate for migrant workers is maintained, causing the existing migrants to maintain their increased labor supply; see Fig. 2.C(i) and 2.C(ii). However, this does not quite match the additional productive capacity provided by the additional migrants so that production of both goods is slightly below, while the price of oil is slightly above, that when additional migration occurs; see Fig. 2.A. In the long run, the individual migrant labor supply increases by about 3.5 p.p., compared to just 0.3 p.p. with additional migration. This reduces the long-run increase in GDP and consumption, resulting from the structural change by about 2.0 and 3.7 p.p., respectively.

The fact that this involves a substantial reduction in native consumption throughout the transition reduces the intertemporal welfare gains substantially from 9.41% to 2.86%. Contrary to what is sometimes suggested, unrestricted immigration benefits the host country. Its long-run effects on the employment of native workers are negligible, while the added productive capacity increases the consumption enjoyed by native inhabitants.

From Figs 2.B and 2.C we see that differences in the effects of the higher oil prices on the developing economy due to the migration of workers are more diffuse. The fact that the oil price is higher in the absence of migration has a more adverse effect on production in the home economy, which in the long run declines by 5.93%. The reduction in the fraction of time stayers allocate to work is also reduced, implying that they enjoy more leisure time. In addition, the higher income earned by migrants increases the amount that each remits back home, and although the number of migrants is now reduced, the fact that output in the home economy is also reduced implies that the R/Y ratio is now higher. This mitigates the loss in consumption experienced by stayers, and taken in conjunction with their increased leisure, stayers actually enjoy a slight increase in intertemporal welfare, although not across steady states. This welfare increase comes at the expense of the fixed migrant workers who, although they consume more, also have less leisure. Nevertheless, the impact on stayers dominates and overall we find, paradoxically, that the home economy may actually be better off under restrictive migration.

5.3 Policy responses

With the higher oil price having an adverse effect on the developing economy, this raises the question of appropriate policy responses to mitigate this outcome. In addressing this, we shall restrict ourselves to the scenario in which migration is ongoing. We compare two alternative tax cuts; a reduction in the fuel tax, and a cut in the tax on labor income. Panel (iii) of Table 3 summarizes the steady-state effects of these changes, while Fig. 3 illustrates the transitional paths.

Reducing the tax on oil usage from 34% to 24% effectively cuts the increase in the price paid by the developing country by about one third. In the short run, the oil tax cut approximately offsets the price increase, keeping the aggregate output roughly unchanged. The immediate fall in oil utilization is reduced and compensated by an increase in the stayers' labor supply. But as migration sets in, due to the sudden increase in the migrant wage rate as a result of increased labor demand in the Middle East economy, the home economy's capital stock also starts to decline, leading to a decline in its aggregate output and labor supply in the long run. The aggregate output contracts by about 2.8 %, compared to a contraction of 4.6 % in the absence of the policy response. The welfare losses for the stayers in the developing economy are also reduced both in the steady state and intertemporally. The same applies to migrants, although for both groups the effects are small. Thus, while the 10 p.p. reduction in the oil tax mitigates the severity of the price increase, it is insufficient to completely eliminate it.

Although a direct cut in the fuel taxes can neutralize the impact of the higher oil price in the immediate short run, over time the outflow of migrant workers puts downward pressure on the developing economy. Thus, a more appropriate policy response is to discourage labor migration by cutting the tax rate on labor income. In fact, reducing the tax on wages from 30% to 20% can effectively reverse the adverse impacts of the shock. Aggregate output jumps due to a large increase in the domestic residents' labor supply. The simulations suggest an interesting nonlinearity in the transition. It seems that the initial increase in migrant wage rate outweighs the net domestic wage, resulting in an initial outmigration which leads to a slight decline in domestic GDP in early stages of the transition. However, as the capital stock is accumulated, pushing up the domestic wage rate, migrant workers return home and thus the aggregate output gradually increases to a permanently higher steady state level, 6.9 % above the initial equilibrium level. Both stayers and migrants enjoy higher consumption levels, thus neutralizing the adverse welfare impact of the oil shock. As the higher migrant wage allows migrant to consume more, without increasing their labor, individual migrant workers can enjoy slight welfare gains.

We have also briefly considered a third tax cut, reducing the capital income tax rate to 15% to boost capital investment. While we find that this can neutralize the long-run adverse impacts of the oil price shock on aggregate output and reduce welfare losses, it is less effective than is a comparable reduction in the tax on labor income, and hence we omit further discussion.

As expected, and is evident from Fig. 3.A, tax policy responses implemented by the small developing economy have minimal impacts on the oil producing Middle East economy. They have negligible effects on its long-run GDP, while the reduction in the intertemporal welfare gains are around 1 p.p. This is because the tax changes, being introduced by the home country do not directly affect the majority of workers in the host economy, who are either native born or come from elsewhere, and not subject to the tax jurisdiction of the home economy.

6. Variations in oil dependence in developing economy

Lim et al. (2023) examined the robustness of the setup with regard to the nature of the migrant workers and migration costs and found that the results to be relatively insensitive with respect to variations in the relevant parameters. In the present case, we focus on parameters pertaining to the production structure of the developing economy, and specifically the role of oil, as described by (i) the elasticity of substitution in production, ζ, and its intensity, ϑ_o. This is important since, although data on these crucial parameters are sparse, they are subject to substantial variation across economies.[28]

[28] See e.g. Duffy and Papageorgiou (2000) for variations in the empirical estimates of ζ across developing economies and Schubert and Turnovsky (2011) for variations in ϑ_O

Panel (a) of Table 4 reports the long-run effects of the higher oil price for ζ = -0.2, i.e. an elasticity of substitution equal to 0.83. With more substitutability of inputs in production, the developing economy and migrant workers become more resilient to the oil shock. Comparing these results to the benchmark parameters in Table 3, aggregate output drops by 3.5% (vs 4.5%). This is due to a larger cut in oil input with less reduction in the usage of capital and labor. The steady-state and intertemporal welfare losses are also less severe. The oil price hike still draws a substantial increase in migrant workers. But, because the developing economy is less affected by the shock, migrant workers remit less, and are able to enjoy more consumption as well as more leisure. As a result, the aggregate welfare losses for the developing economy are reduced by about half, 1.47% (vs 2.8% in Table 3). The evidence in regard to the size of elasticities is consistent with the long-standing argument for the degree of economic flexibility to absorb the shock; see Behrman (1972). Furthermore, the policy response by cutting taxes on labor income is even more effective. A 10 p.p. cut boosts aggregate output by over 8%, and improve of welfare of individual stayers and migrant workers by about 1.4% and 4.2%, respectively.

The benchmark simulation assumes $\vartheta_o = 0.04$, which implies the oil utilization share of GDP of 7.9%. However, as noted, the share of oil consumption varies substantially across countries. For example, the petroleum consumption share of GDP in Cambodia amounted to over 9% in 2022 (U.S. Energy Information Administration). To see the sensitivity to this parameter we increased ϑ_o to 0.08. The results provided in panel (b) of Table 4 show that the impact of the rising oil price on the developing economy and migrant workers are more severe. Aggregate output contracts by 7.13% (vs 4.56% in Table 3) with oil utilization falling over 21%. Both individual and aggregate welfare losses almost double, with intertemporal and steady-state stayers' losses reaching roughly 4.24% (vs 2.16%) and 5.76% (vs 3.4%), respectively. Migrant workers have to send more remittances, cutting into their consumption and leisure, thus incurring a larger welfare loss as well. Overall, cutting the tax rate on labor income from 30% to 20% becomes much less effective in mitigating the adverse impact of the higher oil price.

7. Conclusions

The dramatic rise in the price of oil in recent years has coincided with a large increase in labor migration, particularly from developing economies in South Asia to the oil rich Middle East countries. This phenomenon raises an important question about its impact on the macroeconomic performance of the developing country and the welfare of its constituents. On the one hand, the economy suffers an adverse supply shock which raises the cost of production, but on the other, there is a large outflow of migrant workers, who then send large sums of remittances back home.

To address this issue, we have considered the macro-dynamic equilibrium linking two small economies – an oil-producing, advanced economy and an oil-consuming, developing economy. A key feature of this setup is that by endogenizing migration it highlights the distinction between the decision to migrate and the migrant workers' decision to supply their labor. This distinction is important in understanding the interaction between the flow of migrant workers, their income, and their remittances, as they respond to an endogenously determined higher oil price.

Extensive simulations show that the model can reasonably approximate the empirical evidence characterizing the co-movements of oil prices, migration and remittances. Endogenizing migration provides a coherent linkage between these three important variables, confirming that the relationship is not just spurious. The model suggests a sharp contrast between the short-run and long-run impacts of a rising oil price on the developing economy, as the migrant worker-remittance relationship evolves. On impact, a higher oil price raises the wage of migrant workers, inducing the current stock of migrants to immediately increase their labor supply. With the developing economy's output adversely affected by the shock, migrants send more remittances. Over time, the higher migrant wage attracts more workers to the oil-producing economy, their wage rate is driven down, causing individual migrant workers to reduce their labor supply, thereby offsetting to some degree the remittances sent by the additional migrants.

This dynamic has profound implications for the welfare of the residents in the developing economy, as well as the migrant workers, themselves. The oil price increase immediately reduces the consumption of the stayers, although this is moderated by the increase in remittances that are initially sent by existing migrant workers as a result of their wage increase. This continues over time as more migrant workers move to the oil-producing economy, although at a declining rate. As a result, the welfare of individual stayers decreases, with their collective welfare declining even more due to labor migration. In contrast, the consumption of individual migrant workers instantly rises on impact, but declines with the falling wage rate over time. Their individual welfare declines, but the increase in their numbers causes their collective steady-state welfare to increase.

The process of ongoing migration yields sharply different consequences from those obtained when the number of migrant workers are fixed by a quota system, such as the *Kafala* sponsorship system established in the 1970s. In that case, the adverse impact of a higher oil price impact on the output of the developing economy is more pronounced. Several causes may contribute to this.[29] First, the absence of additional migrant workers and their contribution to the productive capacity of the host country exacerbates (albeit slightly) the resulting equilibrium increase in the oil price. Second, the maintained higher migrant wage and the resulting higher level of remittances allow the stayers cut down on their labor supply and to enjoy more leisure. The increase in leisure and consumption leads to an intertemporal welfare improvement for the stayers at the expense of migrant workers who have to work more.

To offset these adverse impacts, we have compared alternative responses in tax policy by the developing economy. These include primarily, cutting taxes on oil and labor income, and briefly alluding to reducing the tax on capital income. Of these alternatives, reducing the tax on labor income is the most effective. It can eliminate the welfare losses to the residents of the developing economy, while increasing the consumption of migrant workers sufficiently, so that their welfare improves. However the ability to accomplish this is possible only if the developing economy is not too oil dependent.

As expected, in all scenarios the overwhelming bulk of the benefits from the structural change and the resulting increase in the price of oil accrue to the oil producing economy. These

[29] This is also consistent with the empirical evidence alluded to earlier suggesting that the oil shocks of the 1970s (when the kalafa system was introduced) had more adverse effects than the more recent shocks, at which point the quote system had been somewhat relaxed.

benefits are in fact enhanced by allowing ongoing migration to occur, rather than imposing a quota on migrants. There is no evidence of migrant workers taking the jobs of natives, and indeed their contribution to the productive capacity increases the GDP by around 2 p.p. Furthermore, any of the policy responses introduced by the home economy to alleviate any unfavorable effects have virtually no adverse consequences for the oil producing economy.

By relating the determination of the oil price to the industrial policies adopted by the oil producing economies, we are providing a new perspective with respect to the impact of oil prices on oil consuming economies which typically treat them as exogenous. But in implementing policies such as Vision 2021 and Vision 2030 the UAE and Saudi Arabia (respectively) are concerned primarily with the implications for their own economies. While we have alluded only briefly to the existence of these policies, as providing the underlying motivation for the endogenous increase in oil price, they clearly merit further detailed study, offering interesting perspectives on their impact on domestic objectives and their potential consequences abroad.

As a final caveat, we wish to point out that our focus was motivated by the longer run relationship between the rising oil price, increased migration of Bangladeshi workers to Middle East countries, and the increased remittances that generally characterized the period 1990-2020. We view our model as being rather successful in capturing this complex relationship. However, since peaking again in mid-2022 at around US$110 per barrel, the oil price has been steadily declining to around US$65 by mid-2025. This reversal in oil price raises the question of whether the implications of the model are correspondingly reversed. As a simple check, we have changed the host country's production allocation ν from 0.65 to 0.75 and find that this does indeed reverse the results. Most notably, the model implies that oil price declines by 14%, the share of migrant workers drops from 3.51% to 3.37%, and the remittance to GDP (R/Y) ratio declines from 4.14% to 3.89%, with the welfare of the constituent groups being correspondingly impacted. But the Bangladesh experience over that period is more complex. While it saw a significant decrease in the migration of Bangladeshi workers, including deportation, it was also associated with an increase in the R/Y ratio.[30] This is a reflection of the reality of the period being one of great uncertainty, with COVID-19, Trump tariffs, increased inflation, all having an impact and collectively likely dominating the more gradual decline of oil price.

[30] According to data provided by the Bangladesh Bureau of Statistics the remittance to GDP averaged 5.04% during the four years between FY20 and FY 23.

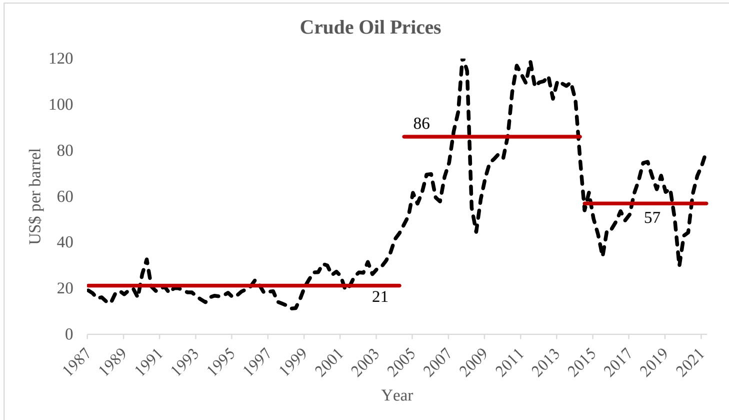


Fig 1.A

Crude Oil Price

Source: Crude oil prices: Brent – Europe taken from Federal Reserve Economic Data (FRED)

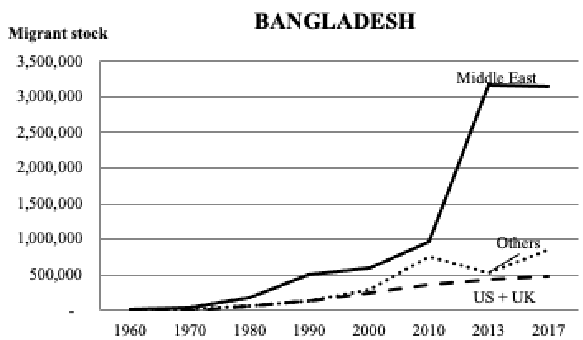
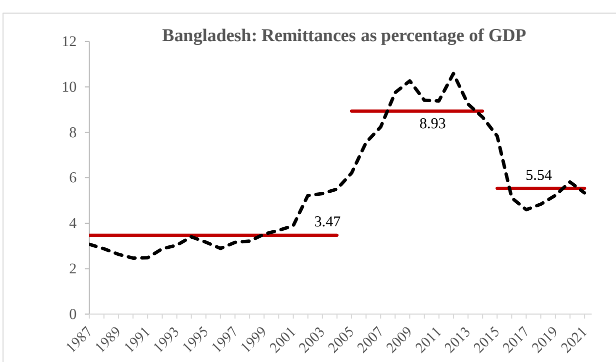


Fig 1.B

Migrant Stock from Bangladesh

Source: World Bank's Global Bilateral Migration Database



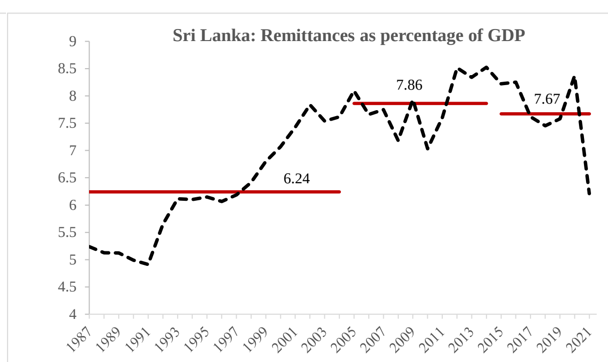


Fig. 1.C **Fig 1.D**

Remittances as percentage of GDP

Source: World Bank's World Development Indicators

Table 1: Baseline parameter values

Parameters of the benchmark economies
Common parameters for both countries:
Utility: $\beta = 0.05; \gamma = -1.5; \sigma = 1.75$
World interest rate: $r^* = 0.035$
The Middle East
Production: $A_h = 2; \alpha_k = 0.36; \alpha_n = 0.83; \phi = 0.04; \xi = -1; \theta_1 = 14; \theta_2 = 3; \chi_h = 0.85; \delta_h = 0.05$
Production possibility frontier: $\nu = 0.65$
Borrowing constraint: $d = 0.02$
The developing economy
Production: $A = 1; \vartheta_k = 0.25; \vartheta_o = 0.04; \zeta = -0.5; \delta = 0.05; \chi = 0.85$
Borrowing constraint: $b = 0.05$
Government: $g = 0.15; \tau_c = 0.15; \tau_k = 0.25; \tau_w = 0.3; \tau_z = 0.34$
Migrant workers
Utility: $\sigma_m = 2.5$
Migration cost: $a = 5; x = 0.15; h = 25$
Oil market
Rest of world oil demand: $A_J = 1.3; \varphi = 1.25$

Table 2: Steady-state values of the benchmark economies

Benchmark steady-state equilibrium values

Variables	Description	Benchmark	Data	Sources
A. The Middle East				
$\tilde{K}_h/\tilde{Y}_h$	Capital-output ratio	3.8532	2.823 [1.247 – 7.439]	PWT
$\tilde{C}_h/\tilde{Y}_h$	Consumption-output ratio	0.6577	0.328 [0.086 – 0.793]	PWT
$\tilde{p}\,\tilde{Z}/\tilde{Y}_h$	Oil production as share of GDP	0.3636	0.328 [0.192 – 0.383]	WDI
$(\theta_1+\theta_2)\,\tilde{m}$	Share of migrants in the host country	0.5969	0.62 [0.32 – 0.88]	WDI
$\tilde{N}_h$	Native labor supply	0.3003	0.3 [0.30 – 0.40]	Cooley (1995)
$\tilde{w}_h$	Native wage rate	6.8958		
B. The developing economy				
$\tilde{K}/\tilde{Y}$	Capital-output ratio	1.4891	2.121 [1.234 – 3.327]	PWT
$\tilde{p}\tilde{O}/\tilde{Y}$	Share of oil utilization	0.0791	6.273 [5.514 – 6.873]	WDI
$\tilde{C}/\tilde{Y}$	Consumption-output ratio	0.7477	0.731 [0.702 – 0.782]	PWT
$\tilde{R}/\tilde{Y}$	Remittance-output ratio	0.0414	0.036 [0.024 – 0.051]	World Bank
$\tilde{B}/\tilde{Y}$	Debt-output ratio	0.2978	0.293 [0.177 – 0.445]	WDI
$\tilde{N}$	Domestic labor supply	0.2494	0.252 [0.217 – 0.287]	BBS (2013)
$\tilde{w}$	Domestic wage rate	0.6494		
C. Migrant workers				
$\tilde{m}$	Fraction of migrant workers	0.0351	0.032 [0.023 – 0.045]	UN
$\tilde{N}_m$	Migrant workers' supply of labor	0.4698	> .417	Rajan et al. (2015)
$\tilde{w}_m$	Migrant wage rate	1.6200		

Notes:
Share of oil utilization is the energy use (kg of oil equivalent) per $100 GDP.
The remittance-GDP ratio is that from the Middle East which is calculated as 56% of total remittances.
Fraction of migrant workers in Bangladesh is the share of its labor force.
Bangladesh Bureau of Statistics (BBS, 2013) reports that Bangladeshi males work on average 6.9 hours a day while females work 5.2 hours a day.
Oil production (% of GDP) are the average of Saudi Arabia, United Arab Emirates, Oman, Kuwait, Bahrain, and Qatar from 2003 to 2015.
Most data are taken from Penn World Table (PWT) for period 1990-2014 and World Bank's World Development Indicators Online for period 1990-2015. Remittance data come from World Bank's (2016) Bilateral Migration and Remittances Database for period 2010-2015 and migrant data come from the United Nations' International Migrant Stock Database – the 2017 Revision.

Table 3: Reduction in the Middle East's Oil Supply

		A. The Middle East							
		Z	p	H	Y_h	K_h	C_h	N_h	ΔW_h ΔW_h^s
Benchmark		2.7481	0.5547	2.6679	4.1922	16.153	2.7570	30.03%	--
(i)	$v: 0.65 \to 0.4$ with endogenous m	2.0173 (-26.59%)	0.7110 (+28.18%)	4.2560 (+59.53%)	5.6903 (+35.74%)	22.074 (+36.65%)	3.8191 (+38.52%)	30.12% (+0.08%pts)	+9.41% +38.23%
(ii)	$v: 0.65 \to 0.4$ with constant m	1.9954 (-27.39%)	0.7172 (+29.30%)	4.1735 (+56.44%)	5.6045 (+33.69%)	21.743 (+34.61%)	3.7162 (+34.79%)	30.03% (-0.00%pts)	+2.86% +34.80%
(iii)	Policy responses with endogenous m								
	$\tau_z: 34\% \to 24\%$	2.0177 (-26.58%)	0.7114 (+28.26%)	4.2541 (+59.45%)	5.6895 (+35.72%)	22.071 (+36.64%)	3.8176 (+38.47%)	30.11% (+0.08%pts)	+8.63% +38.18%
	$\tau_w: 30\% \to 20\%$	2.0139 (-26.72%)	0.7129 (+28.52%)	4.2376 (+58.84%)	5.6733 (+35.33%)	22.009 (+36.25%)	3.7976 (+37.74%)	30.10% (+0.06%pts)	+8.44% +37.52%

B. The Developing Economy (Stayers)

		R/Y	K	O	N	Y	C	$\Delta\omega_d$ / $\Delta\omega_d^s$	ΔW_d / ΔW_d^s
Benchmark		4.14%	0.3376	0.0323	24.94%	0.2267	0.1695	--	--
(i)	$v: 0.65 \rightarrow 0.4$	5.14%	0.3222	0.0261	24.61%	0.2164	0.1636	-2.73%	-2.16%
	with endogenous m	(+1.00%pts)	(-4.56%)	(-19.12%)	(-0.33%pts)	(-4.56%)	(-3.50%)	-2.76%	-3.40%
(ii)	$v: 0.65 \rightarrow 0.4$	7.08%	0.3176	0.0256	24.12%	0.2133	0.1644	+1.15%	+1.15%
	with constant m	(+2.94%pts)	(-5.93%)	(-20.74%)	(-0.82%pts)	(-5.93%)	(-3.02%)	-1.16%	-1.16%
(iii)	Policy responses with endogenous m								
	$\tau_z: 34\% \rightarrow 24\%$	5.00%	0.3283	0.0280	24.84%	0.2204	0.1652	-2.22%	-1.04%
		(+0.86%pts)	(-2.78%)	(-13.27%)	(-0.09%pts)	(-2.78%)	(-2.56%)	-2.34%	-2.94%
	$\tau_w: 30\% \rightarrow 20\%$	4.16%	0.3611	0.0292	27.44%	0.2425	0.1799	-0.10%	+0.79%
		(+0.02%pts)	(+6.94%)	(-9.53%)	(+2.50%pts)	(+6.94%)	(+6.09%)	-0.01%	-0.15%

		C. Migrant Workers					Developing Economy's Total Welfare
		m	N_m	C_m	$\Delta\omega_m$ $\Delta\omega_m^s$	ΔW_m ΔW_m^s	ΔW ΔW^s
Benchmark		3.51%	46.98%	0.3436	--	--	--
(i)	$v: 0.65 \rightarrow 0.4$ with endogenous m	4.15% (+0.64%pts)	47.30% (+0.32%pts)	0.3361 (-2.18%)	-4.33% -3.64%	-16.97% +13.93%	-2.68% -2.80%
(ii)	$v: 0.65 \rightarrow 0.4$ with constant m	3.51% --	50.51% (+3.53%pts)	0.3738 (+8.79%)	-9.38% -8.45%	-9.38% -8.45%	+0.78% -1.41%
(iii)	Policy responses with endogenous m						
	$\tau_z: 34\% \rightarrow 24\%$	4.10% (+0.59%pts)	47.25% (+0.27%pts)	0.3378 (-1.69%)	-4.19% -2.92%	-26.39% +13.19%	-1.93% -2.37%
	$\tau_w: 30\% \rightarrow 20\%$	3.65% (+0.14%pts)	46.96% (-0.02%pts)	0.3516 (+2.33%)	+0.89% +2.43%	-17.94% +6.37%	+0.13% +0.08%

Table 4: Robustness checks

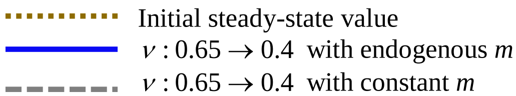
A. The Middle East									
		Z	p	H	Y_h	K_h	C_h	N_h	ΔW_h ΔW_h^s
(a) ζ = -0.2 **Benchmark**		2.7357	0.5548	2.6550	4.1729	16.079	2.7359	30.01%	--
(i)	$v: 0.65 \rightarrow 0.4$ with endogenous m	2.0076 (-26.61%)	0.7110 (+28.14%)	4.2356 (+59.53%)	5.6630 (+35.71%)	21.968 (+36.63%)	3.7890 (+38.49%)	30.10% (+0.08%pts)	+9.36% +38.20%
(ii)	Policy response $\tau_w: 30\% \rightarrow 20\%$	2.0033 (-26.77%)	0.7127 (+28.46%)	4.2160 (+58.79%)	5.6439 (+35.25%)	21.895 (+36.17%)	3.7656 (+37.63%)	30.07% (+0.06%pts)	+8.44% +37.41%
(b) ϑ_o = 0.08 **Benchmark**		2.7683	0.5537	2.6923	4.2250	16.279	2.7945	30.07%	--
(i)	$v: 0.65 \rightarrow 0.4$ with endogenous m	2.0318 (-26.60%)	0.7098 (+28.20%)	4.2937 (+59.48%)	5.7359 (+35.76%)	22.251 (+36.68%)	3.8714 (+38.53%)	30.15% (+0.08%pts)	+9.57% +38.25%
(ii)	Policy response $\tau_w: 30\% \rightarrow 20\%$	2.0296 (-26.68%)	0.7117 (+28.54%)	4.2776 (+58.88%)	5.7221 (+35.43%)	22.198 (+36.35%)	3.8532 (+37.88%)	30.14% (+0.07%pts)	+8.54% +37.65%

B. The Developing Economy (Stayers)									
		R/Y	K	O	N	Y	C	$\Delta\omega_d$ $\Delta\omega_d^s$	ΔW_d ΔW_d^s
(a) $\zeta = -0.2$									
Benchmark		3.86%	0.3922	0.0209	24.96%	0.2385	0.1831	--	--
(i)	$v: 0.65 \to 0.4$	4.72% (+0.87%pts)	0.3785 (-3.50%)	0.0164 (-21.52%)	24.72% (-0.24%pts)	0.2301 (-3.50%)	0.1795 (-1.99%)	-1.52% -1.45%	-0.96% -2.09%
(ii)	Policy response $\tau_w: 30\% \to 20\%$	3.80% (+0.06%pts)	0.4238 (+8.06%)	0.0183 (-12.30%)	27.53% (+2.57%pts)	0.2577 (+8.06%)	0.1974 (+7.80%)	+1.06% +1.41%	+1.96% +1.30%
(b) $\vartheta_o = 0.08$									
Benchmark		4.72%	0.3052	0.0464	24.26%	0.2050	0.1447	--	--
(i)	$v: 0.65 \to 0.4$	6.03% (+1.31%pts)	0.2835 (-7.13%)	0.0365 (-21.30%)	23.77% (-0.49%pts)	0.1904 (-7.13%)	0.1357 (-6.18%)	-4.80% -5.12%	-4.24% -5.76%
(ii)	Policy response $\tau_w: 30\% \to 20\%$	4.90% (+0.18%pts)	0.3185 (+4.36%)	0.0410 (-11.73%)	26.60% (+2.34%pts)	0.2139 (+4.36%)	0.1493 (+3.16%)	-2.12% -2.35%	-1.23% -2.54%

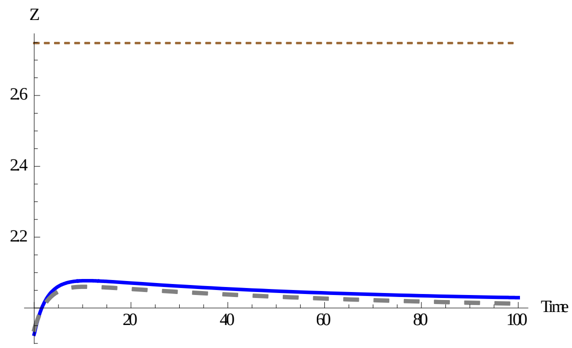
	m	N_m	C_m	$\Delta\omega_m$ $\Delta\omega_m^s$	ΔW_m ΔW_m^s	ΔW ΔW^s
	C. Migrant Workers					**Developing Economy's Total Welfare**
(a) ζ = -0.2 **Benchmark**	3.49%	46.12%	0.3622	--	--	--
(i) $v: 0.65 \rightarrow 0.4$	4.13% (+0.64%pts)	46.29% (+0.16%pts)	0.3578 (-1.21%)	-2.76% -1.97%	-15.64% +15.87%	-1.47% -1.47%
(ii) Policy response $\tau_w: 30\% \rightarrow 20\%$	3.60% (+0.11%pts)	45.97% (-0.15%pts)	0.3748 (+3.47%)	+2.48% +4.21%	-16.66% +7.29%	+1.31% +1.51%
(b) ϑ_o = 0.08 **Benchmark**	3.55%	48.59%	0.3101	--	--	--
(i) $v: 0.65 \rightarrow 0.4$	4.20% (+0.65%pts)	49.20% (+0.61%pts)	0.2981 (-3.84%)	-7.01% -6.66%	-19.28% +10.35%	-4.77% -5.18%
(ii) Policy response $\tau_w: 30\% \rightarrow 20\%$	3.74% (+0.19%pts)	48.79% (+0.20%pts)	0.3113 (+0.41%)	-1.85% -0.57%	-20.27% +4.82%	-1.90% -2.28%

Figure 2: Reduction in the Middle East's Oil Production

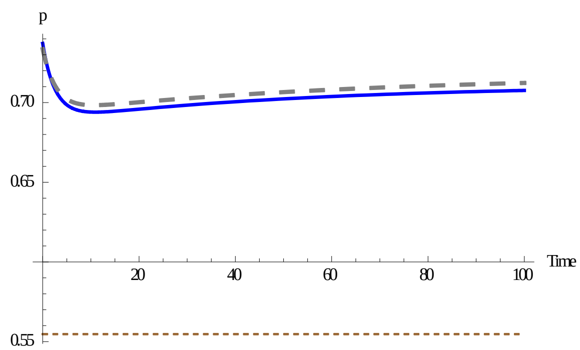
Endogenous m vs constant m



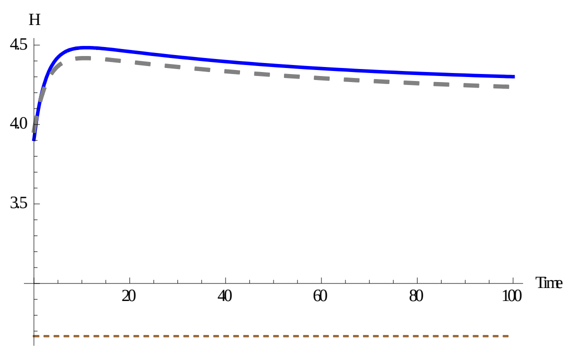
A. The Middle East



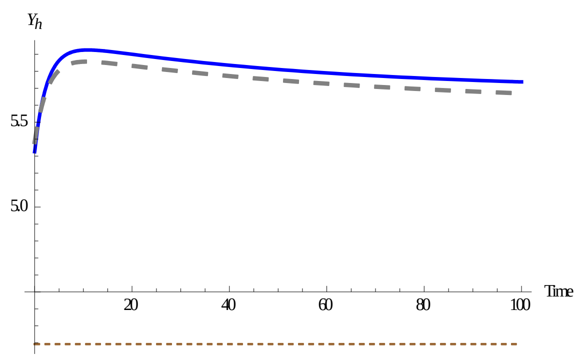
(i) Oil production



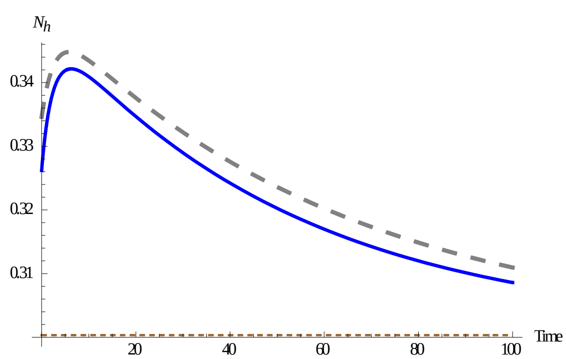
(ii) Oil price



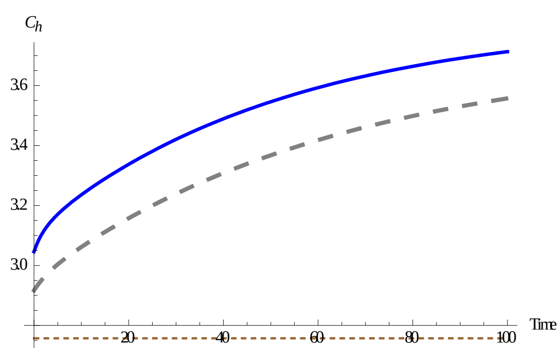
(iii) Traded good



(iv) Total output

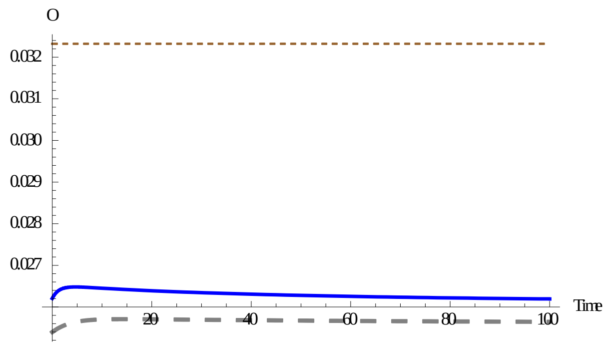


(v) Native labor supply

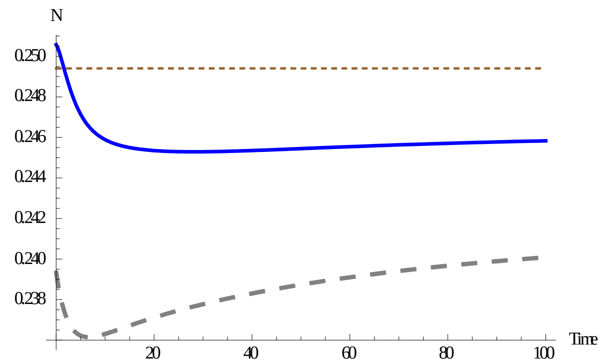


(vi) Native consumption

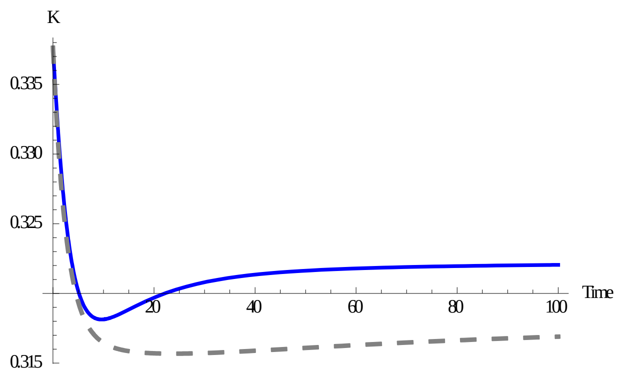
B. The Developing Economy



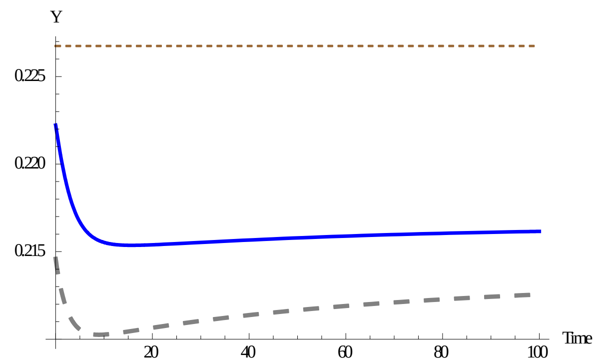
(i) Oil utilization



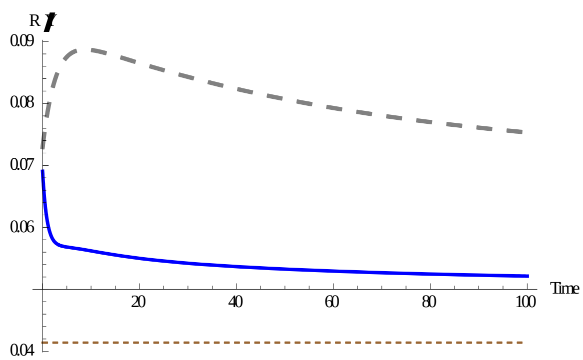
(ii) Labor supply



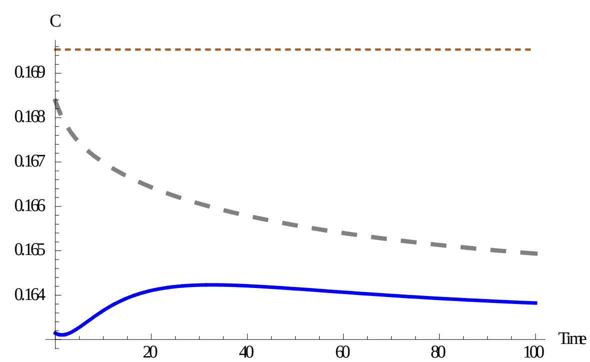
(iii) Capital stock



(iv) Output

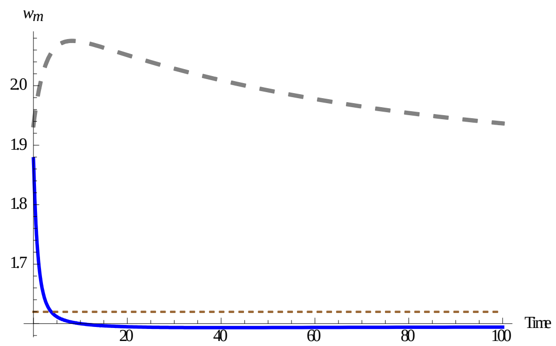


(v) Remittance-output ratio

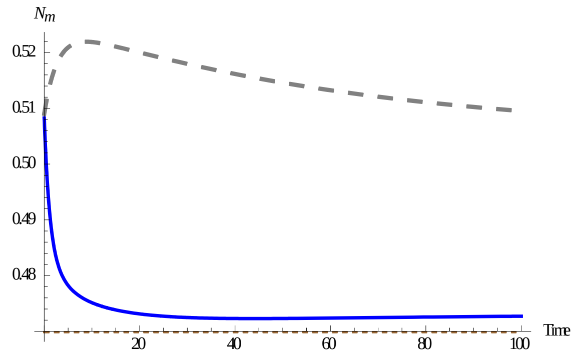


(vi) Consumption

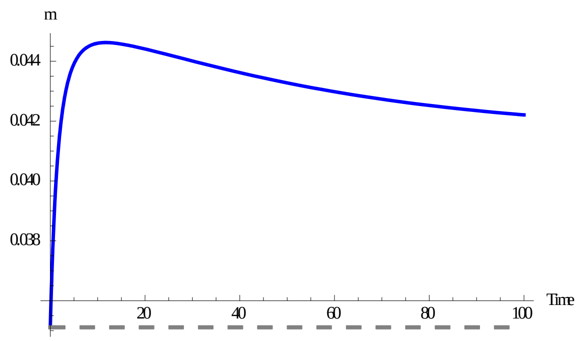
C. Migrant Workers



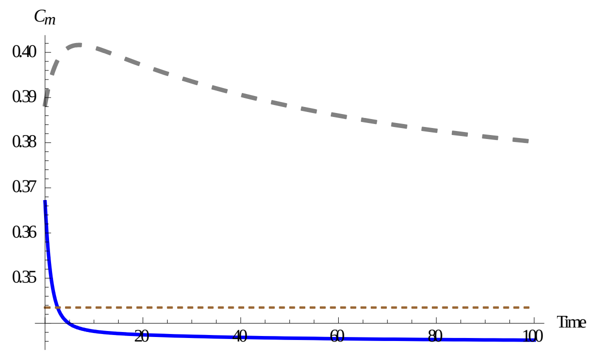
(i) Migrant wage



(ii) Migrant labor supply



(iii) Migrant workers



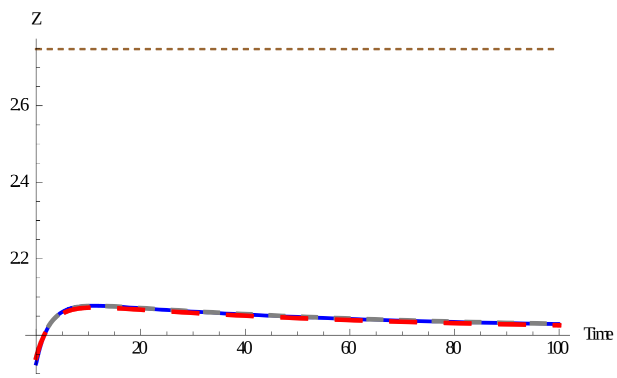
(iv) Migrant consumption

Figure 3: Reduction in the Middle East's Oil Production

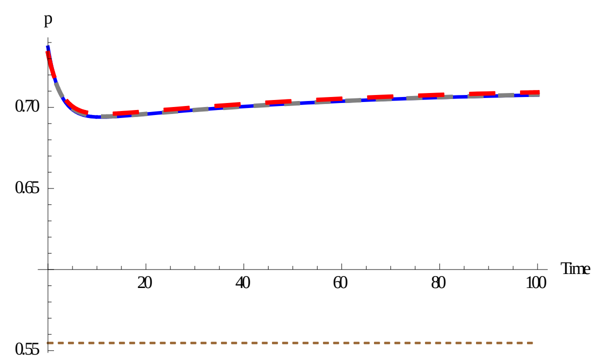
Tax policy responses

Initial steady-state value
$\nu: 0.65 \rightarrow 0.4$
$\tau_z: 34\% \rightarrow 24\%$
$\tau_w: 30\% \rightarrow 20\%$

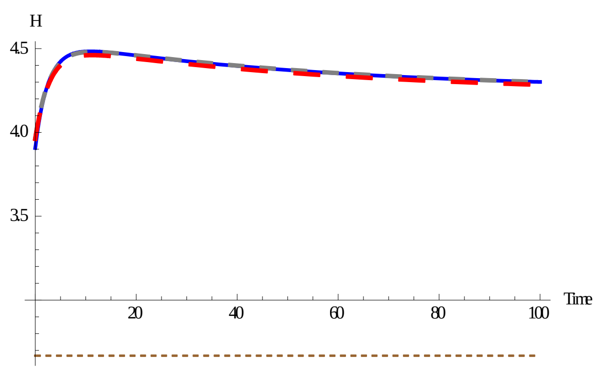
A. The Middle East



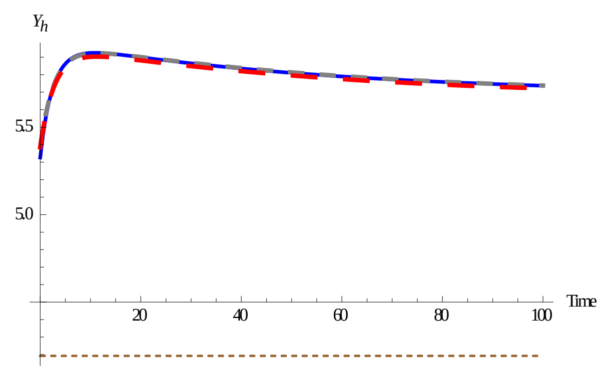
(i) Oil production



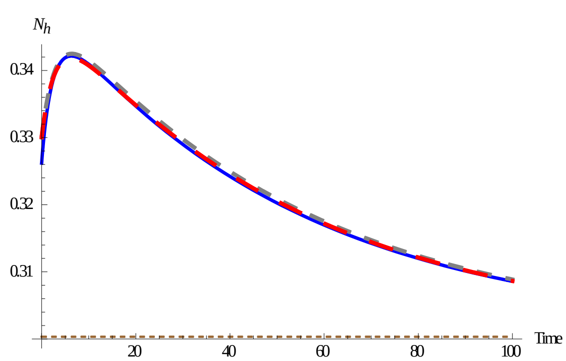
(ii) Oil price



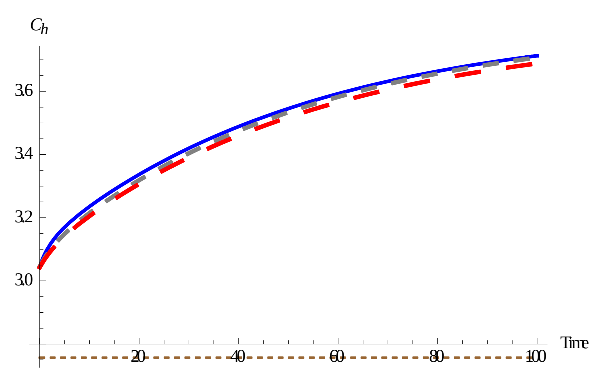
(iii) Traded good



(iv) Total output

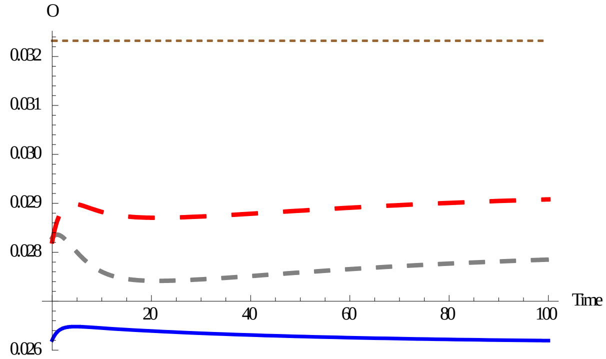


(v) Native labor supply

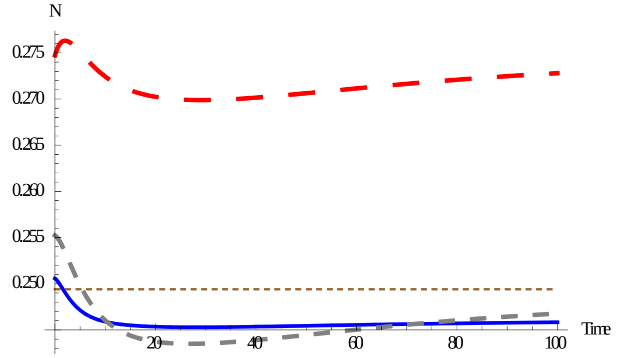


(vi) Native consumption

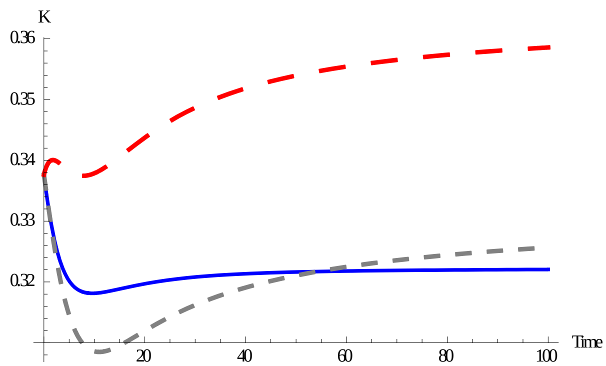
B. The Developing Economy



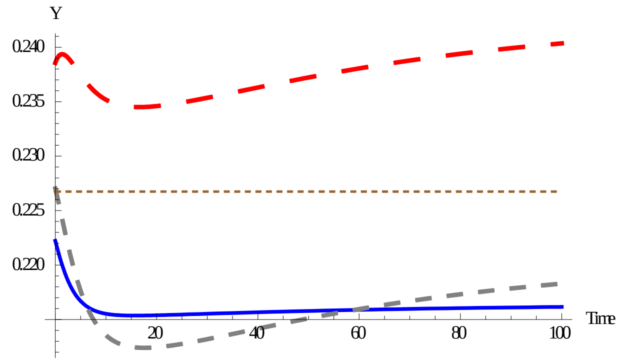
(i) Oil utilization



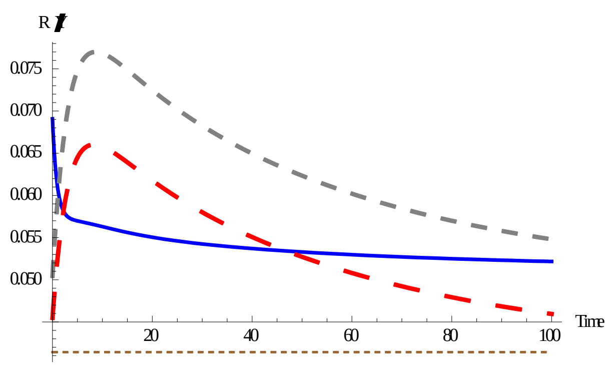
(ii) Labor supply



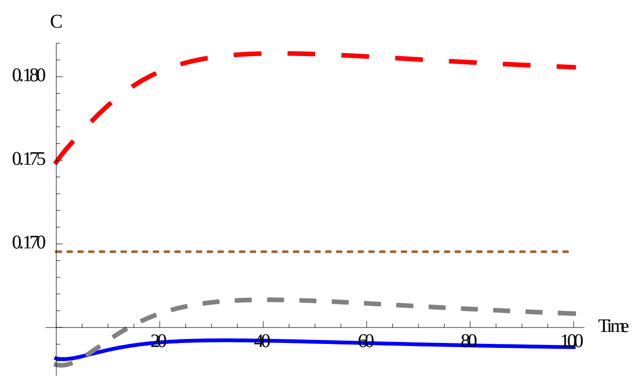
(iii) Capital stock



(iv) Output

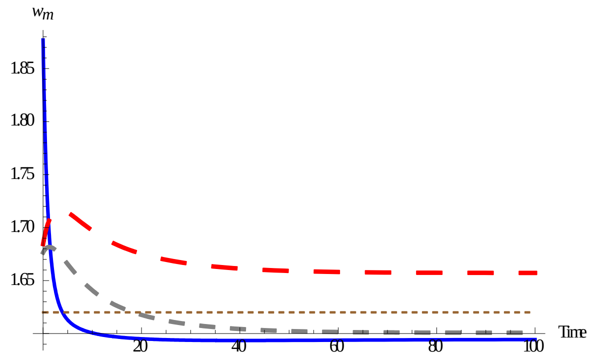


(v) Remittance-output ratio

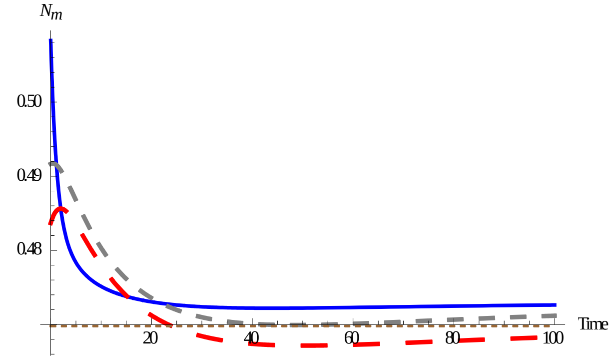


(vi) Consumption

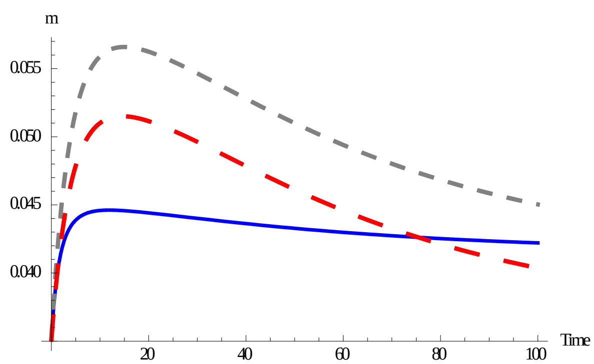
C. Migrant Workers



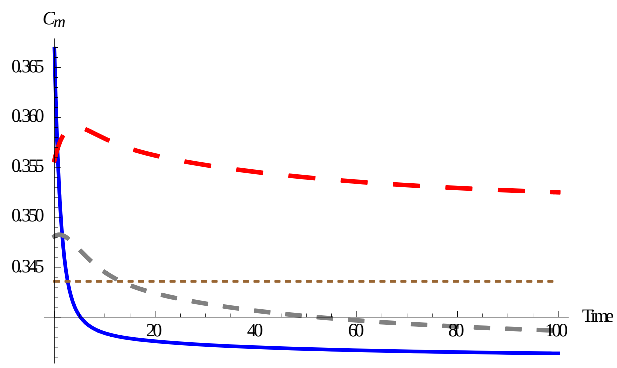
(i) Migrant wage



(ii) Migrant labor supply



(iii) Migrant workers



(iv) Migrant consumption

Appendix

A. Macrodynamic equilibrium

The macrodynamic equilibrium is described by the following system of differential equations summarizing the dynamics of the two economies and their interaction:

A.1 Oil-producing host economy

$$\dot{B}_h = r_h B_h + C_h + \frac{q_h^2 - 1}{2\chi_h} K_h - \frac{X_{K_h}(K_h, N_h, \theta(m) N_m)}{T_H(H,Z)} K_h - \frac{X_{N_h}(K_h, N_h, \theta(m) N}{T_H(H,Z)} N_h \tag{A.1a}$$

$$\dot{\pi} = \pi\left(\beta - r_h\right) \tag{A.1b}$$

$$\dot{K}_h = \left(\frac{q_h - 1}{\chi_h} - \delta_h\right) K_h \tag{A.1c}$$

$$\dot{q}_h = q_h\left(r_h + \delta_h\right) - \frac{X_{K_h}(K_h, N_h, \theta(m) N_m)}{T_H(H,Z)} - \frac{\left(q_h - 1\right)^2}{2\chi_h} \tag{A.1d}$$

A.2 Migrant workers

$$\dot{m} = \frac{s-a}{h} \tag{A.1e}$$

$$\begin{aligned}\dot{q} = rq &- \frac{M\left(C_m, L_m\right) - U\left(C, L\right)}{U_C\left(C, L\right)}\left(1 + \tau_c\right) - \left[\frac{X_{\theta(m)N_m}}{T_H} N_m - x - C_m\right] \\ &+ \left[\left(1 - \tau_w\right) F_{(1-m)N_Y} N - \left(1 + \tau_c\right) C\right]\end{aligned} \tag{A.1f}$$

A.3 Developing home economy

$$\begin{aligned}\dot{B} = rB + \frac{q^2 - 1}{2\chi} K + \left(1 - m\right) C + \frac{T_Z\left(Z, H\right)}{T_H\left(Z, H\right)} O - \left(1 - g\right) F\left(K, O, \left(1 - m\right) N\right) \\ - m\left[\frac{X_{\theta(m)N_m}}{T_H} N_m - C_m - x\right] + \frac{a\left(s - a\right)}{h} + \frac{\left(s - a\right)^2}{2h}\end{aligned} \tag{A.2a}$$

$$\dot{\lambda} = \lambda\left(\beta - r\right) \tag{A.2b}$$

$$\dot{K} = \left(\frac{q - 1}{\chi} - \delta\right) K \tag{A.2c}$$

$$\dot{q} = q\left(r + \delta\right) - \left(1 - \tau_k\right) F_K\left(K, O, \left(1 - m\right) N\right) - \frac{\left(q - 1\right)^2}{2\chi} \tag{A.2d}$$

Defining for notational convenience $z \equiv (K_h, q_h, B_h, \pi, m, s, K, q, B, \lambda)$, linearizing this system around the steady state, $\tilde{z} \equiv (\tilde{K}_h, \tilde{q}_h, \tilde{B}_h, \tilde{\pi}, \tilde{m}, \tilde{s}, \tilde{K}, \tilde{q}, \tilde{B}, \tilde{\lambda})$ we may express the local equilibrium dynamics, in the compact matrix form:

$$\dot{z} = A(z - \tilde{z}) \tag{A.3}$$

where $A \equiv (a_{ij})$ are the appropriate partial derivatives. Of these ten dynamically evolving variables, K_h, B_h, m, K, and B are constrained to evolve gradually, while q_h, π, s, q, and λ are free to respond instantaneously as new information becomes available. The numerical simulations presented in subsequent sections demonstrate that the system is characterized by five stable (negative) and five unstable (positive) eigenvalues, so that the macro equilibrium yields a unique stable saddle path. The stable solutions for K_h, q_h, B_h, π, m, s, K, q, B, and λ can be written in the following forms

$$K_h(t) = \tilde{K}_h + \sum_{i=1}^{5} Q_i e^{\mu_i t} \tag{A.4a}$$

$$q_h(t) = \tilde{q}_h + \sum_{i=1}^{5} \nu_{2,i} Q_i e^{\mu_i t} \tag{A.4b}$$

$$q_h(t) = \tilde{q}_h + \sum_{i=1}^{5} \nu_{3,i} Q_i e^{\mu_i t} \tag{A.4c}$$

$$\pi(t) = \tilde{\pi} + \sum_{i=1}^{5} \nu_{4,i} Q_i e^{\mu_i t} \tag{A.4d}$$

$$m(t) = \tilde{m} + \sum_{i=1}^{5} \nu_{5,i} Q_i e^{\mu_i t} \tag{A.4e}$$

$$s(t) = \tilde{s} + \sum_{i=1}^{5} \nu_{6,i} Q_i e^{\mu_i t} \tag{A.4f}$$

$$K(t) = \tilde{K} + \sum_{i=1}^{5} \nu_{7,i} Q_i e^{\mu_i t} \tag{A.4g}$$

$$q(t) = \tilde{q} + \sum_{i=1}^{5} \nu_{8,i} Q_i e^{\mu_i t} \tag{A.4h}$$

$$B(t) = \tilde{B} + \sum_{i=1}^{5} \nu_{9,i} Q_i e^{\mu_i t} \tag{A.4i}$$

$$\lambda(t) = \tilde{\lambda} + \sum_{i=1}^{5} \nu_{10,i} Q_i e^{\mu_i t} \tag{A.4j}$$

where μ_i i = 1-5 denote the stable eigenvalues, the vector $(1, v_{2,i}, v_{3,i}, v_{4,i}, v_{5,i}, v_{6,i}, v_{7,i}, v_{8,i}, v_{9,i}, v_{10,i})$ is the normalized eigenvector associated with the stable eigenvalue, μ_i, and the constants, Q_i, are obtained by imposing the given initial values on the 5 sluggish variables K_h, B_h, m, K, and B. Once the transitional paths for K_h, q_h, B_h, π, m, s, K, q, B, and λ are determined by (A.4), we can derive the implied dynamics for C_h, N_h, H, Z, C, N, C_m, N_m, O, and p.

B. Steady State

In the long run, provided appropriate stability conditions are met, which our simulations satisfy, both economies converge to a steady-state in which all variables are constant through time. Setting $\dot{K}_h = \dot{q}_h = \dot{B}_h = \dot{\pi} = \dot{m} = \dot{s} = \dot{K} = \dot{q} = \dot{B} = \dot{\lambda} = 0$ in eqs. (A.1), (A.2) yields the steady state values for the host oil-producing economy and the home developing economy, respectively.

B.1 The oil-producing host economy

$$T\left(\tilde{H},\tilde{Z}\right) = X(\tilde{K}_h, \tilde{N}_h, \theta(\tilde{m})\tilde{N}_m) \tag{B.1a}$$

$$\frac{T_Z\left(\tilde{H},\tilde{Z}\right)}{T_H\left(\tilde{H},\tilde{Z}\right)} = \tilde{p} \tag{B.1b}$$

$$\frac{V_{L_h}\left(\tilde{C}_h,\tilde{L}_h\right)}{V_{C_h}\left(\tilde{C}_h,\tilde{L}_h\right)} = \frac{X_{N_h}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)} \tag{B.1c}$$

$$\tilde{N}_h + \tilde{L}_h = 1 \tag{B.1d}$$

$$\frac{X_{K_h}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)}\tilde{K}_h + \frac{X_{N_h}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)}\tilde{N}_h = \beta\tilde{B}_h + \frac{\tilde{q}_h^2 - 1}{2\chi_h} + \tilde{C}_h \tag{B.1e}$$

$$\beta = r^* + \Psi\left(\frac{\tilde{B}_h}{\tilde{H} + \tilde{p}\tilde{K}_h}\right) = \frac{1}{\tilde{q}_h}\left[\frac{X_{K_h}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)} + \frac{\left(\tilde{q}_h - 1\right)^2}{2\chi_h}\right] - \delta_h \tag{B.1f}$$

$$\tilde{q}_h = \delta_h\chi_h + 1 \tag{B.1g}$$

$$\tilde{Z} = \tilde{O} + A_J \left[\frac{T_Z\left(\tilde{H},\tilde{Z}\right)}{T_H\left(\tilde{H},\tilde{Z}\right)} \right]^{-\varphi} \tag{B.1h}$$

B.2 The developing home economy

$$F_O\left(\tilde{K},\tilde{O},\left(1-\tilde{m}\right)\tilde{N}\right) = \tilde{p}\left(1+\tau_z\right) \tag{B.2a}$$

$$\frac{U_L\left(\tilde{C},\tilde{L}\right)}{U_C\left(\tilde{C},\tilde{L}\right)} = \left(\frac{1-\tau_w}{1+\tau_c}\right) F_{(1-m)N}\left(\tilde{K},\tilde{O},\left(1-\tilde{m}\right)\tilde{N}\right) \tag{B.2b}$$

$$\frac{M_{C_m}\left(\tilde{C}_m,\tilde{L}_m\right)}{U_C\left(\tilde{C},\tilde{L}\right)} = \frac{1}{1+\tau_c} \tag{B.2c}$$

$$\frac{M_{L_m}\left(\tilde{C}_m,\tilde{L}_m\right)}{M_{C_m}\left(\tilde{C}_m,\tilde{L}_m\right)} = \frac{X_{\theta(m)N_m}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)} \tag{B.2d}$$

$$\tilde{N} + \tilde{L} = 1 \tag{B.2e}$$

$$\tilde{N}_m + \tilde{L}_m = 1 \tag{B.2f}$$

$$\frac{M\left(\tilde{C}_m,\tilde{L}_m\right) - U\left(\tilde{C},\tilde{L}\right)}{U_C\left(\tilde{C},\tilde{L}\right)}\left(1+\tau_c\right) + \tilde{R} - \left[\left(1-\tau_w\right)F_{(1-m)N}\left(\tilde{K},\tilde{O},\left(1-\tilde{m}\right)\tilde{N}\right)\tilde{N} - \left(1+\tau_c\right)\tilde{C}\right] = a\beta \tag{B.2g}$$

$$\tilde{R} = \tilde{m}\left[\frac{X_{\theta(m)N_m}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)}\tilde{N}_m - \tilde{C}_m - x\right] \tag{B.2h}$$

$$\beta = r^* + \Gamma\left(\frac{\tilde{B}}{F\left(\tilde{K},\tilde{O},\left(1-\tilde{m}\right)\tilde{N}\right)}\right) = \frac{1}{\tilde{q}}\left[\left(1-\tau_k\right)F_K\left(\tilde{K},\tilde{O},\left(1-\tilde{m}\right)\tilde{N}\right) + \frac{\left(\tilde{q}-1\right)^2}{2\chi}\right] - \delta \tag{B.2i))}$$

$$\beta\tilde{B} + \frac{q^2-1}{2\chi}\tilde{K} + \left(1-\tilde{m}\right)\tilde{C} + \tilde{p}\tilde{O} = \left(1-g\right)F\left(\tilde{K},\tilde{O},\left(1-\tilde{m}\right)\tilde{N}\right)$$
$$+\tilde{m}\left[\frac{X_{\theta(m)N_m}\left(\tilde{K}_h,\tilde{N}_h,\theta\left(\tilde{m}\right)\tilde{N}_m\right)}{T_H\left(\tilde{H},\tilde{Z}\right)}\tilde{N}_m - \tilde{C}_m - x\right] \tag{B.2j}$$

$$\tilde{q} = \delta\chi + 1 \tag{B.2k}$$

$$\tilde{s} = a \tag{B.2l}$$

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