

INTERNATIONAL REMITTANCES, MIGRATION, AND PRIMARY COMMODITIES

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This paper documents the global crude oil market as a key driver of international migration and remittances. Structural estimation documents that crude oil supply and demand shocks induce sizeable remittances flows. The sign and magnitude of remitter outflows differ across countries and structural shocks. A multilateral global general equilibrium model is used to show how oil-exporting remitters generate international remittance and migration spillovers from crude oil price movements. Remittees' economic outcomes from remittances and migration channels are found to be dominated by terms of trade channels for shocks to the global market for crude oil. Due to this, studies of remittance flows need to account for the source of the commodity price movement if using the correlation of remittee real GDP and remittance inflows.

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1 Introduction

Remittances, the unrequited, nonmarket personal transfers of earned income by expatriate workers to their country of origin, constitute a large share of international capital flows and an important source of financial inflows to developing countries. An important link exists between remittances and migrant flows with the global market for crude oil. Many remitters are oil producers, such as the Gulf Cooperation Council countries and Russia, potentially making remittance flows susceptible to movements in oil prices. Moreover, economies that are dependent on remittance inflows tend to be oil-importers (see, for example, Choucri (1986) and Ahmed (2013)). Hence, oil prices may have important consequences for both remitter and remittee economies, apart from the role of remittances.

This is the first structural study of migration and remittances in the presence of endogenous primary commodity markets. The analysis introduces two novel models – a structural multilateral global general equilibrium model as well as a structural empirical method, both with endogenous global crude oil markets.

The relationship between oil prices and remittances has been casually examined in Choucri (1986) and Ahmed (2013) and formally estimated in panel models for the Gulf Cooperation Council countries by Ratha and others (2015) and Naufal and Termos (2009). These panel and gravity-type models lack structural interpretation and ignore the source of the underlying price movement. Structural empirical analysis has been used to examine remittance dynamics, but they have not considered endogenous global commodity markets. For example, Lueth and Ruiz-Arranz (2007) employ a vector-error-correction model to estimate remittance dynamics for Sri Lanka. Mughal and Ahmed (2014) propose a structural vector auto-regression to decompose the remittance flow into host and home economy shocks for a number of South Asian countries, but the authors do not consider the source of global oil price movements.

This is the first study to examine whether the source of the global oil price movements matters for remittance flows. Distinguishing between the sources of underlying crude oil price movement is critical since they have different consequences on macro-aggregates (see, for example, Kilian (2009) among others). Structural empirical estimates show that the sign and magnitude of remitter outflows differ across regions and structural shocks to the global market for crude oil.

Empirical estimates find that remittance outflows from Saudi Arabia are more stable than those from Russia, particularly for shocks to domestic demand and foreign oil supply. The sign of the remittance outflows also differs across the two countries for the foreign demand shock. A foreign demand shock increases remittance outflows in Russia, but decreases remittance outflows in Saudi Arabia. This may reflect different remittance motives across the regions, with the marginal propensity to remit countercyclical to foreign activity in Saudi Arabia.

The structure of the empirical estimates is motivated by a proposed dynamic, stochastic, general equilibrium (DSGE) model of the global economy with endogenous commodity markets for crude oil, metals, and agricultural goods. A related literature of DSGE models of international business cycles of Durdu and Sayan (2008), Acosta and others (2009), and Chami et al. (2006), examines remittance endowment shocks in a small-open-economy general-equilibrium framework. However, they refrain from modeling labor migration. Klein and Ventura (2009) model endogenous labor movements in a two-location growth model, but abstract from remittances. Mandelman and Zlate (2012) model international labor migration and remittances a two region DSGE model, but as with

all the above mentioned papers do not model multiple regions or commodity prices.

To this end, this paper proposes the first multilateral-global DSGE model with endogenous remittances, migration, and primary commodity markets. In particular, the model has several regions and includes both oil-exporting and oil-importing economies. The main migration-remittances corridors are explicitly modelled in the multilateral framework. This allows for a formal decomposition of the contribution of remittances versus other channels for international spillovers such as from primary commodity terms of trade changes. Both supply and demand shocks to the global market for crude oil are found to be an important source of remittance and migration transmission across regions. The multilateral framework of the DSGE model highlights how changes in remittance inflows need not originate from the region with the underlying economic disturbance but can come through third country effects, such as international spillovers from the global market from crude oil.

The literature on the determination of remittance outflows in remitter economies has primarily focused on the relationship between remittance flows and the output fluctuations of home and host economies. Remittance flows are consistently found to be positively correlated with the host economies' GDP. In contrast, the evidence suggests that remittance flows differ in how they respond to home countries' GDP, although countercyclical correlations are predominate (Chami and others 2005, 2008; Frankel, 2011; Sayan, 2004). These studies primarily employ panel estimates and gravity-type models that lack structural interpretation and are subject to issues with endogeneity. The structural analysis of this paper suggests that trade and primary commodity channels dominate the remittee real GDP response. This implies that the behavioral incentive to migrate and remit cannot be deduced from correlations of real GDP and remittance inflows.

The paper is structured as follows. Section 2 introduces the structural general equilibrium model of migration and international remittance flows. Section 3 proposes a method to estimate remitter dynamics using structural vector auto regressions and includes the calibration strategy of the structural model. Section 4 conducts scenario analysis using the general equilibrium structural model. Section 5 discusses the implications of the analysis of the structural model for the identification of the motive to remit and migrate. Section 6 concludes.

2 A Multilateral DSGE Model of Remittances and Migration

This section provides an overview of the model structure and documents the labor migration and remittance channels. Section 2.1 provides a non-technical overview of the non-labor and remittance channels. Section 2.2 provides a non-technical overview of the remittances and labor migration channels. Section 2.3 provides a technical overview of the proposed remittance and labor migration channels.

2.1 Non-Technical Overview

The remittance and labor migration channels are built into the International Monetary Fund's (IMF) Flexible System of Global Models (FSGM). This framework is explicitly designed for the examination of international spillovers in a globally consistent, stock-flow system for scenario analysis and forecasting. FSGM is an annual, multi-region, general equilibrium model of the global economy. There are nine modules, each with a unique multi-region composition sharing a common

forward-looking theoretical framework. The theoretical foundations and dynamic properties of the model apart from the migration and remittance mechanism are extensively described in Andrle and others (2015). For the sake of brevity, this paper provides a technical overview of the novel remittances and migration channels and a non-technical overview of the other aspects of the model. Readers may consult Andrle and others (2015) for a complete technical description of the specific functional forms for other aspects of the model.

To allow for more individual country/region coverage, FSGM employs a simplified semi-structural formation for select sectors. FSGM's key behavioral elements, including private consumption and investment, are micro-founded, whereas trade, labor supply, and inflation have reduced-form representations. The sectors that are reduced-form are designed to be consistent with the properties of the IMF's micro-founded structural models such as GIMF, the Global Integrated Monetary and Fiscal model (Kumhof and others, 2010; Anderson and others, 2013), and GEM, the Global Economy Model (Pesenti, 2008). In addition, the semi-structural framework allows for more empirical determination of the dynamic properties and heterogeneity of the behavior of individual countries. The gains of country/region coverage are not inconsequential, with each module including roughly two dozen countries/regions. With nine modules, almost all large economies and all regions are modelled (see Appendix 1 for a complete description).

Households consist of both overlapping generation (OLG) households that consume out of a stock of wealth that is discounted beyond that of their standard rate of time preference and a set of liquidity constrained households (LIQ) that consume their present income. The presence of the LIQ agents is an important additional non-Ricardian feature. The presence of the OLG households implies that changes in household wealth from changes in government debt have significant economic implications. This results from a share of associated tax liabilities falling outside of OLG households' planning horizon. It also implies that aggregate saving, net foreign assets, and the global equilibrium real interest rate are endogenous, with the real interest rate adjusting to equilibrate the global supply and demand for saving.

There is a fully specified fiscal sector with several policy instruments. There is full stock-flow accounting of fiscal policy with a fiscal balance that accumulates to a stock of debt and tracking of the interest burden of debt. Fiscal policy stabilizes debt as a percent of GDP and responds to temporary domestic conditions by varying fiscal instruments in response to changes in the output gap. Monetary policy follows an inflation-forecast-based interest rate reaction function, or is modeled as a hard peg or managed floating exchange rate consistent with the monetary policy framework in the country. All currency unions are modeled as such.

Exports and imports are modeled with reduced-form equations. Exports increase with foreign activity and with the depreciation in the real competitiveness index. Imports increase with domestic activity and with the appreciation of the real effective exchange rate (REER). The model replicates the Balassa-Samuelson effect from a relative increase in the productivity of the tradable sector. Time-varying trade shares are designed to mimic the properties of multiple-good structural models and are a function of the relative level of tradable and nontradable productivity within each country.

The stock of private capital is chosen by firms to maximize their present discounted profits. Investment follows a Tobin's Q specification with quadratic real adjustment costs. A corporate risk premium based on Bernanke and others (1999) follows a reduced form relationship and responds to the domestic output gap. Potential output is based on Cobb-Douglas production technology with

trend total factor productivity, trend labor, and the actual capital stock. The unemployment rate of the native population follows an Okun's Law relationship.

The consumer price index excluding food and energy, CPIX, is the core price in all regions and is determined by an inflation Phillips curve. Prices are sticky and there are channels for oil prices to leak into core inflation through the pass-through of higher oil prices in the marginal costs of production. Corresponding deflators exist for headline (including food and energy), the government, investment, imports and exports. A Phillips curve for wages exhibits price stickiness and responds to the evolution of overall economic activity.

The model includes three primary commodity markets – crude oil, agricultural goods, and metals. These three sectors provide richness in international spillovers with appropriate responses for production and demand of commodities in both exporters and importers. The demand for commodities is driven by world demand, and it is relatively price inelastic based on estimated short run elasticities of the respective sectors. The supply of commodities is also price inelastic in the short run. Oil is consumed by households, used in manufacturing, imported and exported. The behavior of oil in consumption, imports and exports are governed by reduced form equations. Agricultural goods and metals follow a similar structure except that metals are not consumed directly by households.

Primary commodities affect the economy through several channels. Food and oil feed into the consumption basket and pass through into headline inflation which deflates real disposable income and wealth. Metals and oil affect the cost of production. Consequently, commodity prices have an impact on the demand for capital and labor through production. As mentioned above, oil prices can pass through into core inflation which can elicit a response of the monetary policy authority.

Overall, the structure of FSGM serves as an ideal platform for the incorporation of remittances and migrant labor. The detailed structure of consumption, production, and fiscal and monetary policy can capture key differences in the structure of domestic economies. Moreover, the accounting of trade and the international spillovers from primary commodities provides a plausible benchmark on which to incorporate spillovers from international remittance flows.

2.2 Non-Technical Overview of Remittances

Households of working age in their home country provide migrant labor to foreign economies. When a worker travels abroad, they reduce the population of their country and increase that of the foreign economy. The model allows for labor emigration to be drawn from either the labor force or non-participating population. This can be calibrated for each region/country. These labor market dynamics are fully reflected in domestic participation rates. For the baseline, it is assumed worker emigration does not change the unemployment rate of the expatriates country.

Foreign workers are assumed to have full employment in the host economy and influence accordingly the participation and unemployment rates. Importantly, the number of migrants and their share in the labor force is endogenous. The share of foreign labor in aggregate employed labor is motivated by a Leontief-type labor production technology for total labor supply. Changes in labor demanded drive both the share of expatriate workers in total labor and bilateral migration. Changes in total labor migration drive bilateral migration based on the exact bilateral shares from the most recent data. Expatriate workers can have a different level of productivity relative to native workers resulting in distinct wages for both native and expatriate workers.

Foreign workers remit a fixed share of their after-tax earning to their home country. The fixed marginal propensity to remit (MPR) in the baseline analysis is a medially stance on behavioural dynamics given the absence of a consensus on the behavioural incentives to remit (such as warm-glow or investment purposes). Varying the behavioural incentive to remit does not qualitatively change the main results, which find that remittance flows are mainly dependant on the number of foreign worker and their after-tax wage earning for shocks to remitter economies (see discussion in Section 5). The remittee economies accepts fixed bilateral shares of each remitter's outflow which is exactly set to the most recent data on bilateral flows. The fixed bilateral shares are appropriate given the focus on shocks to remitter economies and not to remittee economies. The cost of sending remittances through a financial intermediary is explicitly modeled and remittance flows are net of costs. Financial intermediaries of remittances operate at no cost and pay out profits in the form of dividends to OLG households.

In the baseline, remittances are received by only LIQ households of the home economy. The assumption that all remittances are spent is consistent with empirical estimates and case studies suggesting that remittances are primarily used for immediate consumption (World Bank, 2006). As noted by Chami and others (2008), even the share of remittances often attributed to savings is primarily used for the consumption of education and durables. In the data and in FSGM, these are considered consumption goods and hence are assumed not to increase private savings. That said, if remittance flows include persistent changes in the productivity of home workers, the conservative assumption of no productivity effects in this paper would underestimate the output effects from remittance flows.

There are several unique features in the design of the remittance channels to reduce the number of equations in FSGM. The remittance channels are modular, allowing for an economy to be remitter (importer) and/or remittee (exporter) of remittances (labor), or neither.

There are a few simplifying assumptions in the specification of the DSGE model that are driven by lack of data availability. Full participation of migrant workers and fixed productivity differences are simplifying assumptions mainly due to lack of any data on such rates for expatriate workers in the regions of interest. The assumption of full employment may slightly exaggerate the change in migration. However, any effect this may have on migration is rectified by adjusting the estimate of the marginal change in migrant labor demanded given changes in total labor demanded. Hence, this assumption does not bias total bilateral migration. Another consideration is that the wage differential may not be due to differences in productivity per say but discrimination against migrant workers. In this case the assumption of fixed differences in productivity may reduce the responsiveness of the level of migrants' labor income to changes in wages. Importantly, neither of these assumptions changes the main results of this paper but may be interesting avenues for future research as data availability improves.

2.3 Technical Overview of Remittances

The following notation is consistent with Andrle and others (2015). The world consists of \tilde{N} countries. The domestic economy is indexed by $j = 1$ and foreign economies by $j = 2, \dots, \tilde{N}$. Domestic labor variables are denoted by H , representing home, to distinguish from foreign F labor. In the exposition, country indices are ignored except when interactions between multiple countries are concerned. There is positive trend labor augmenting technology T_t with a growth rate

g_t and a positive population growth rate n . Quantities of labor are rescaled by n and real variables are scaled by both technology and population. The hat notation \check{x}_t denotes the real variable of x_t , trend variables are denoted by \check{x}_t^{FE} , and the steady state is denoted by \bar{x} .

2.3.1 Consumption

The domestic labor force consists of a share, $(1 - \lambda^{c,h})$, of OLG households and a share, $\lambda^{c,h}$, of domestic LIQ households. Both types of domestic households earn the wage of domestic workers \check{w}_t^H and together supply aggregate employed domestic labor \check{l}_t^H .

Foreign workers are assumed to consume out of their present after-tax income and hence comprise a share of total LIQ households. Whilst abroad, foreign workers spend, $SP\check{E}NT_t$, and remit a fixed share, MPR , of their after tax labor income. Total spending of foreign workers is given by:

$$SP\check{E}NT_t = (1 - MPR)(1 - \tau_t^l)\check{w}_t^F\check{l}_t^F, \quad (1)$$

where \check{w}_t^F is the wage of foreign workers, and \check{l}_t^F is the stock of employed foreign workers. The share of earnings not spent abroad is remitted by foreign workers to their home economy, PAY_t , subject to a cost:

$$PAY_t = MPR(1 - \tau_t^l)(1 - RCOST_t)\check{w}_t^F\check{l}_t^F, \quad (2)$$

where $RCOST_t$ is the cost of sending remittances through a financial intermediary. The revenue earned by financial intermediaries, $RR\check{E}V_t$ is given by:

$$RR\check{E}V_t = RCOST_t MPR(1 - \tau_t^l)\check{w}_t^F\check{l}_t^F, \quad (3)$$

where $RR\check{E}V_t$ is contemporaneously paid out as a lump sum dividend to OLG households.

The expatriate's home country receives flows of remittances from workers abroad, \check{R}_t :

$$\check{R}_t = \sum_{j=2}^{\tilde{N}} BRSHR(1, j) PAY_t(j) \frac{Z_t(j)}{Z_t}, \quad (4)$$

where $BRSHR(1, j)$ is a fixed bilateral share of country j 's remittances received by the expatriates home economy. Foreign currency is converted to domestic units by Z_t . Hence, changes in the bilateral exchange rates will affect the value of remittances received in domestic units. Remittance flows are accounted for in real gross national product and the current account.

LIQ households consume their present share of domestic after tax labor earnings, LIQ transfers, Υ_t^{LIQ} , their share of general transfers, Υ_t , and lump sum taxes, tax_t^{ls} . LIQ households also consume received remittance flows from abroad \check{R}_t . As migrant workers are assumed to be liquidity constrained, the aggregate consumption of LIQ households is defined as:

$$(1 + \tau_t^C)p_t^C \check{c}_t^{LIQ} = \lambda^{c,h}(\Upsilon_t - tax_t^{ls}) + \Upsilon_t^{LIQ} + \lambda^{c,h}(1 - \tau_t^l)\check{w}_t^H\check{l}_t^H + \check{R}_t + SP\check{E}NT_t, \quad (5)$$

where the tax rate on consumption is given by τ_t^C , and p_t^C is the price of consumption goods.

2.3.2 Labor Demand and Supply

Emigrated labor, \check{l}_t^E , is tracked and given by:

$$\check{l}_t^E = \sum_2^{\tilde{N}} LABSHARE(j, 1) \check{l}_t^F(j), \quad (6)$$

where $LABSHARE(j, 1)$ is the share of country j 's imported labor, $\check{l}_t^F(j)$, supplied by the home economy.

The share of foreign labor in aggregate employed labor is motivated by a Leontief-type labor production function. Specifically, trend foreign labor, $\check{l}_t^{F,FE}$, is given by:

$$\check{l}_t^{F,FE} = \Lambda_0^F + \frac{\alpha^F \Lambda_1^F}{z_t^F} \check{l}_t^{FE} + \epsilon_t^{F,FE}, \quad (7)$$

where α^F is a parameter equal to the steady state share of foreign labor in aggregate labor, and $\epsilon_t^{F,FE}$ is a permanent shock to the foreign labor stock. A constant, Λ_0^F , allows the absorption of permanent changes in aggregate labor by foreign workers to differ from the steady state share of foreign workers in aggregate labor. Generally, $\Lambda_0^F = 0$ and $\Lambda_1^F = 1$, so changes in employed labor are absorbed by foreign laborers based on the share of foreign workers in the steady state share labor force.

The trend stock of foreign labor is distinguished from the actual stock, \check{l}_t^F , so that only the trend level of foreign workers will be used to calculate potential output. The actual stock of foreign labor is given by:

$$\check{l}_t^F = \check{l}_t^{F,FE} + \frac{\alpha^F \Lambda_1^F}{z_t^F} (\check{l}_t - \check{l}_t^{FE}) + \epsilon_t^F, \quad (8)$$

where ϵ_t^F is a temporary shock to the stock of foreign labor. Similar to the steady state equation, this allows for the absorption of temporary changes in labor by foreign workers to differ from the steady state share of foreign labor in total labor. This specification also implies that labor flows are driven entirely by pull factors, i.e. labor demand in the host country.

The economies population, \check{N}_t , is given by:

$$\check{N}_t = \check{N}_t^H + \check{l}_t^F, \quad (9)$$

where \check{N}_t^H is the domestic born working age population. The population of domestically-born residents is given by:

$$\check{N}_t^H = \check{N}_t^B - \check{l}_t^E, \quad (10)$$

where \check{l}_t^E is the stock of emigrated labor and \check{N}_t^B is all persons born in an economy. Hence emigration reduces the population of the country. The employed domestic labor, \check{l}_t^H , is given by:

$$\check{l}_t^H = (1 - U_t^H) PART_t^H \check{N}_t^H, \quad (11)$$

where $PART_t^H$ is the participation rate of home's domestic workers, and U_t^H is their unemployment rate. This specification results from a 100 percent employment rate of foreign labor, implying that

the aggregate participation and unemployment rates differ from that of domestic workers.

Aggregate unemployment rates operate via an Okun's law. The unemployment rate of total labor force, U_t , and that of the domestic labor force are related by:

$$U_t = \frac{U_t^H PART_t^H \check{N}_t^H}{PART_t^H \check{N}_t^H + \check{l}_t^F}. \quad (12)$$

Similarly, the participation rate of total working age population, $PART_t$ is given by:

$$PART_t = \frac{PART_t^H \check{N}_t^H + \check{l}_t^F}{\check{N}_t}. \quad (13)$$

The total employed labor force, \check{l}_t , becomes the sum of domestic and foreign workers:

$$\check{l}_t = \check{l}_t^H + \check{l}_t^F, \quad (14)$$

The labor augmenting productivity of foreign and domestic workers are denoted by z_t^F and z_t^H , respectively. The productivity of home workers, z_t^H , is unity in steady state and is included only as a shock, so z_t^F defines the steady-state relative productivity of foreign versus home workers. The effective wage, \check{w}_t^φ , per unit of labor is derived from the marginal product of labor and defines the labor factor share $(1 - \alpha_t)$, where earnings are given by:

$$\check{w}_t^\varphi \check{l}_t^\varphi = \check{w}_t^H \check{l}_t^H + \check{w}_t^F \check{l}_t^F = (1 - \alpha_t) \check{y}_t p_t^y, \quad (15)$$

where p_t^y is the price of output, and \check{l}_t^φ is the effective labor force defined by $\check{l}_t^\varphi = z_t^H \check{l}_t^H + z_t^F \check{l}_t^F$. Wages of foreign and domestic-born workers are defined by $\check{w}_t^F = z_t^F \check{w}_t^\varphi$ and $\check{w}_t^H = z_t^H \check{w}_t^\varphi$, respectively. The economy-wide wage, \check{w}_t , is the weighed average of the wages of domestic-born and foreign-born workers:

$$\check{w}_t = \frac{\check{w}_t^F \check{l}_t^F + \check{w}_t^H \check{l}_t^H}{\check{l}_t}. \quad (16)$$

2.3.3 Balance of Payments and Potential Output

Remittance flows are accounted for in current account flows (measured in relative prices, superscript N), CA_t^N :

$$CA_t^N = TB_t^N - PAY_t^N + R_t^N + INT_{t-1}^{NFA} \frac{NFA_{t-1}^D}{\epsilon_t Z_{t-1} \pi_t g_t n}, \quad (17)$$

where TB_t^N is the trade balance, INT_{t-1}^{NFA} is the nominal interest rate for net foreign assets, ϵ_t is exchange rate depreciation, and π_t is inflation. Remittance flows also enter real gross national product, $G\check{N}P_t$:

$$G\check{N}P_t = G\check{D}P_t + INT_{t-1}^{NFA} \frac{NFA_{t-1}^D}{\epsilon_t Z_{t-1} \pi_t g_t n} \frac{1}{p_t^y} + (\check{R}_t - P\check{A}Y_t) \frac{1}{p_t^y}. \quad (18)$$

Potential output, \check{y}_t^{FE} , is given by:

$$\check{y}_t^{FE} = A_t^{FE} COM_t^{FE} \left(\frac{\check{k}_{t-1}}{g_t n} \right)^{\alpha^{FE}} \left[\left(1 - \frac{U_t^{H,FE}}{100} \right) z_t^H PART_t^{H,FE} \check{N}_t^H + z_t^F \check{l}_t^{F,FE} \right]^{(1-\alpha^{FE})}, \quad (19)$$

where \check{k}_t is the capital stock, \bar{U}_t^H is the NAIRU, and $PART_t^{H,FE}$ is trend participation rate of home workers. Trend total factor productivity is denoted by A_t^{FE} , and the effect on productivity from permanent metal and oil price movements is due to COM_t^{FE} .

3 Calibration of Remittances and Migration in FSGM

This section discusses the method used to calibrate the steady state and dynamics of the DSGE model. The steady state of remittances and migration are exactly set to the latest available bilateral data. A description of the regional foreign labor stocks and remittance flows summarized using the regional compositions of FSGM's modules can be found in Appendix 1.

A structural vector auto regressions (SVAR) is proposed to estimate remittance dynamics from oil-exporting, remitter economies and identify shocks to the global market for crude oil. The SVAR is estimated for Russia and Saudi Arabia. The structural responses of remittances in the SVAR are used to calibrate the dynamics of remittances in the DSGE model as outlined in section 3.2. The DSGE model structurally estimates the labor migration dynamics.

3.1 Structural Estimation of Remittance Dynamics

The SVAR takes the following form:

$$\mathbf{A}(\mathbf{I}_K - \sum_{i=1}^p \mathbf{A}_i L^i) \mathbf{y}_t = \mathbf{B} \mathbf{e}_t$$

where \mathbf{e}_t is a $K \times 1$ vector of orthogonal disturbances, \mathbf{A} is a $K \times K$ lower triangular matrix with ones on the diagonal, \mathbf{B} is a $K \times K$ diagonal matrix, \mathbf{A}_i are $K \times K$ matrices of auto regressive parameters, and \mathbf{y}_t is a $K \times 1$ vector of endogenous variables.

The benchmark model employs a recursive structure with the following ordering: foreign (world excluding home) oil supply, home oil supply, foreign (world excluding home) real GDP, the U.S. refiners real import price of crude oil, home real GDP, and real remittances. Thus, the model attempts to identify shocks to both domestic and home oil supply, foreign and home demand, other oil specific demand, and remittances. The structure is modified appropriately for the United States and the euro area as discussed and reported in Appendix 2.

A variant of Kilian's (2009) methodology is used to estimate shocks to the global market for crude oil. In particular, the methodology assumes that oil supply and real GDP do not respond contemporaneously to oil prices, but oil prices respond contemporaneously to shocks to oil production and demand. The structure is motivated by both empirical evidence and institutional information on the real rigidity in demand and supply and is suitable with models estimated at monthly and quarterly frequency (Kilian, 2009).

The main difference of the method in this paper and that of Kilian (2009) is that the oil supply of the small oil exporting economy (SOE), responds contemporaneously to shocks to foreign oil supply. This modification takes into account the relative slack in Saudi Arabia's and Russia's oil supply, and makes sense especially at a quarterly frequency. The response of oil supply of the SOE (OPEC economies) is found in some cases to be significant given shocks to foreign oil supply shocks.

The model presented in section 2 provides the additional motivation of the remittance and SOE elements of the SVAR. In particular, remittances of the SOE do not drive global business cycles or the real price of crude oil. In addition to the zero restrictions on contemporaneous innovations, which is reflected in the recursive structure, the DGSE model motivates additional zero restrictions on the parameters on lagged variables in the \mathbf{A}_i matrices. In particular, the coefficients for lags of remittances are set to zero in all foreign equations and the SOE oil supply equation, and the coefficients for lags of SOE real GDP are constrained to zero in the foreign equations.

The remittance measure is the sum of personal transfers and employee compensation from the IMF's Balance of Payments databases. This measure is based on residency rather than migrant status. Oil prices are the quarterly average of refiners' imported crude oil price from the Energy Information Administration (EIA). Both remittances and oil prices are in real US\$ and deflated by the U.S. consumer price index from the Federal Reserve Economic Data (FRED). The oil supply series is production of crude oil including lease condensate measured in 1000 barrels per day from the EIA. Real GDP is in US\$, from the World Bank's Global Economic Monitor. Foreign variables are always measured as world excluding that of the home economy. Variables are seasonally adjusted prior to estimation. No evidence of co-integration was found so the model is estimated with all variables in percent change.

The SVAR models are estimated for Russia and Saudi Arabia. Estimates for the United States and the euro area as well as annualized elasticities for all shocks are presented in Appendix 2. The impulse response dynamics for the foreign and home real GDP, and foreign oil supply shocks are presented in the following sections. The impulse responses are normalized so that shocks are one percent on average in the first year, consistent with the tables. The impulse responses are presented with 68 percent confidence intervals (1 standard deviation) which are parametrically bootstrapped with 1000 simulations.

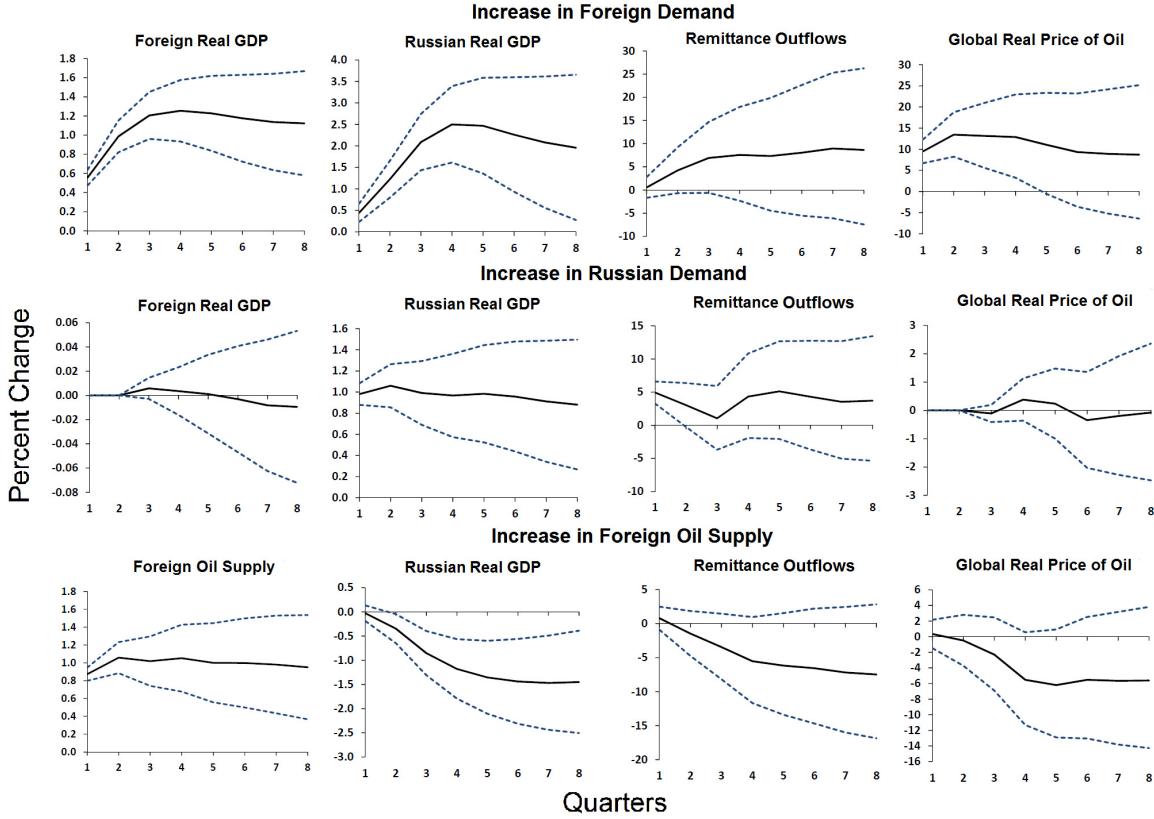
3.1.1 Russia

Figure 1 illustrates the impulse response functions (IRFs) of the structural shocks in the SVAR estimated for Russia. Quarterly data of personal transfers is only available from 2001q1, so is extrapolated back using employee compensation from 1995q1 to 1999q4. The impulse responses of remittance are similar for the models estimated from 1995q1 or 2001q1, so the full data sample is used. The IRFs are normalized so that the shock is one percent on average in the first year.

A foreign demand shock that increases foreign real GDP by one percent on average in the first year puts significant upward pressure on the price of oil by approximately 12.3 percent on average in the first year. Russian oil supply does not significantly respond but Russian real GDP increases significantly by close to 1.6 percent on average in the first year. Remittances outflows increase by close to 4.8 percent on average in the first year.

In response to a domestic demand shock that increases Russian real GDP by one percent in the first year, remittances increase significantly by 3.3 percent. Oil supply in Russia does not

Figure 1. SVAR: Remittance Outflows in Russia



significantly respond. Foreign real GDP, foreign oil supply and the real price of crude oil do not significantly respond consistent with the identification restrictions. The correlation of remittances and Russian real GDP is only slightly less for foreign demand shocks relative to domestic demand shocks.

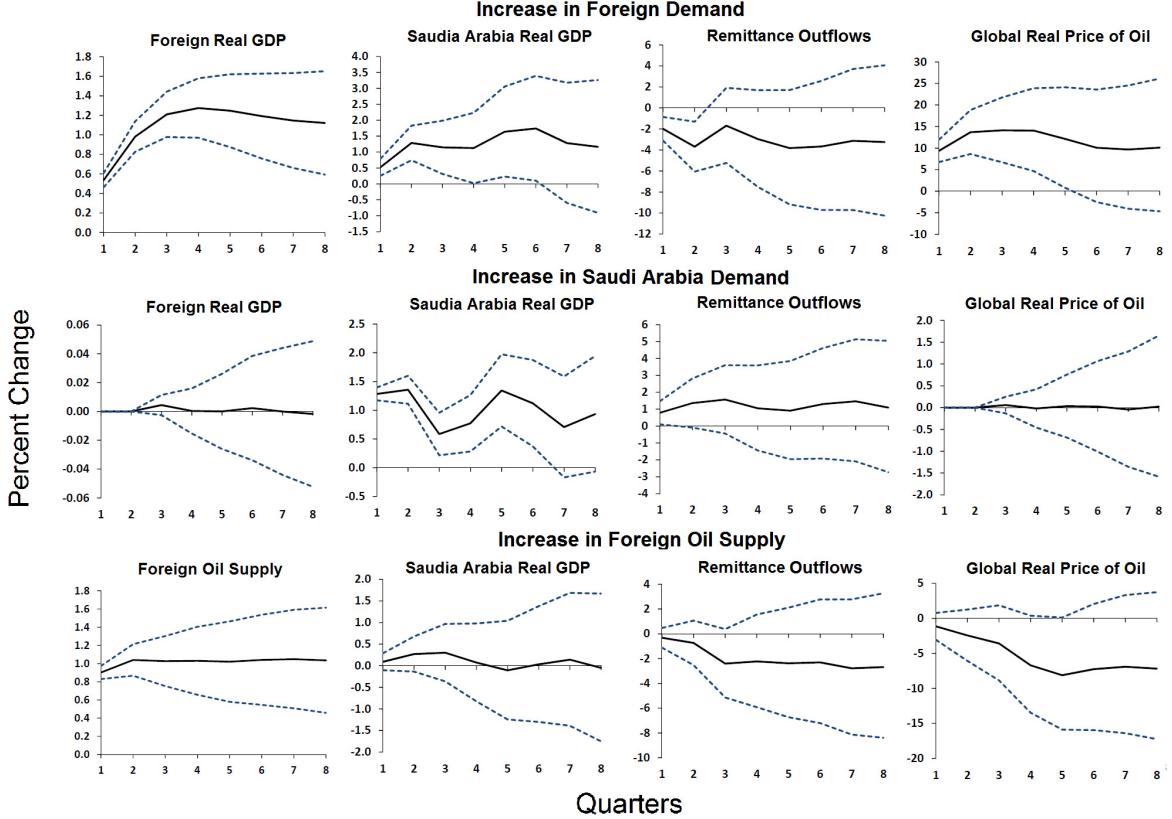
The shock which increases foreign oil supply by one percent on average in the first year generates a 2 and 5.9 percent fall in the real oil price on average in the first and second year, respectively. Russian real GDP falls by 0.6 percent in the first year and remittances outflows decline significantly by just over 2.4 percent on average in the first year. Overall, the estimates for Russia suggest a larger response of remittance outflows relative to real GDP to shocks to foreign oil supply relative to shocks from foreign or domestic real GDP.

3.1.2 Saudi Arabia

Figure 2 illustrates the IRFs of structural shocks in the SVAR estimated for Saudi Arabia. The level of real GDP from the Global Economic Monitor is only available from 2010q1 so the series is extended back using the IMF's International Financial Statistics seasonally adjusted volume index of GDP using year-over-year growth rates prior to 2010q1. The growth rates of the IMFs volume index closely matches the growth rates of the Global Economic Monitor for the overlapping

sample. Moreover, quarterly remittances data for Saudi Arabia is only available from 2006q1 on, so is extrapolated back using annual data and real GDP from 1995q1 to 2005q4. The impulse responses of remittance and real GDP to structural shocks are similar for the models estimated from 1995q1 or 2006q1, so the full 1995q1 to 2015q2 data sample is used.

Figure 2. SVAR: Remittance Outflows in Saudi Arabia



A foreign demand shock that increases foreign real GDP by one percent on average in the first year significantly increases the price of oil by 12.8 percent in the first year. This is consistent with the SVARs estimated for Russia or using global data (see Appendix 2). Saudi real GDP increases by 1 percent on average in the first year accompanied with a 1.3 percent increase in Saudi oil supply. Interestingly, out-flowing remittances fall by 2.6 percent. This fall in remittances is robust across specifications of the SVAR estimated using data prior to 2010q1. Due to data limitations it is not possible to decompose this response into declines in labor inflow, reductions in the marginal propensity to remit, or expatriates wages. This is further complicated by the fact that foreign real GDP may not be correlated with expatriates home economies real GDP. Due to this, the fall in remittances to a rise in foreign real GDP is a puzzle left to be explored in future research.

In response to a demand shock that increases Saudi real GDP by one percent on average in the first year, remittances increase significantly by 1.2 percent. There is no significant response of the price of oil or foreign GDP consistent with the identifying restrictions. The different response of remittances to Saudi real GDP for alternative structural shocks is stark. The results suggest a positive correlation of remittances and Saudi real GDP for shocks to domestic demand, and

negative correlations for the shock to foreign demand.

A shock that increases foreign oil supply by one percent on average in the first year generates a 3.5 percent fall in the price of crude oil in the first year on average. This is slightly more than the estimates from the other SVARs. This possibly arises from the significant 1.3 percent rise in Saudi oil supply in response to a one percent shock to foreign oil supply, resulting in a larger overall oil-supply shock. There is no significant movement in Saudi real GDP in response to an increase in foreign oil supply. Saudi oil supply responses are interesting as they dampen oil price movements from foreign demand shocks but amplify oil price movements from foreign oil supply shocks, possibly consistent with their role as a central Organization of the Petroleum Exporting Countries (OPEC) producer. In response to the increase in foreign oil supply, remittances fall insignificantly by 1.4 percent on average in the first year. Together, the above evidence suggest that remittance outflows are more stable under foreign oil supply shocks in Saudi Arabia relative to Russia.

3.1.3 Summary of Estimated Dynamics

The estimates of the responsiveness of remittance outflows is found to differ across regions and across structural shocks. Generally, remittance outflows from Saudi Arabia are found to be more stable than those from Russia, particularly for shocks to home demand and foreign oil supply. Moreover, remittances outflows from home demand shocks have a larger elasticity with respect to home real GDP than foreign demand shocks in Russia but the opposite is true for Saudi Arabia.

The sign of the remittance outflows is found to differ across the two countries for the foreign demand shock. A foreign demand shock increases remittance outflows in Russia, but decreases remittance outflows in Saudi Arabia. This may reflect different remittance motives across the regions, with the marginal propensity to remit countercyclical to foreign activity in Saudi Arabia.

The structural analysis of the DSGE model is used to identify the dynamics of migrant labor demanded and the marginal propensity to remit out of migrant income. Robustness analysis suggests the magnitudes of remittances and home real GDP are slightly sensitive to shorter sample periods. The next section details the dynamic calibration strategy for FSGM in detail.

3.2 Steady State and Dynamic Calibration of Remittances and Migration

In the general equilibrium model, remittance dynamics are jointly determined by the dynamics of foreign labor, l_t^F , the marginal propensity to remit, MPR_t , and the wage of the foreign workers w_t^F . Unfortunately, the lack of time series data on foreign workers and bilateral migration is a severe restriction on both the study of remitter dynamics, and the understanding of behavioral motives to remit and migrate. The lack of data on foreign labor and wages precludes a formal decomposition of these three channels using the SVAR. However, by using the remittance dynamics from the SVAR the DGSE model is used to estimate the dynamics of international labor flows. To accomplish this, foreign wage dynamics are assumed to follow those of home workers and the marginal propensity to remit is backed out of the DSGE model jointly with foreign labor dynamics to match the remittance dynamics from structural shocks in the SVAR.

The stock of foreign labor, l_t^F , in steady state is set to the most recent estimates available, 2010 and 2013, from Ratha and Shaw (2007). Foreign labor stocks for other years are extrapolated

assuming a fixed share of foreign labor in total labor. The dynamics of foreign labor are determined by Λ_1^F . Note that trend foreign labor, equation 7, includes a constant, Λ_0^F , implying that changes to Λ_1^F do not determine the steady-state stock of workers but instead determine the marginal absorption of changes in aggregate labor by foreign workers. For example, if $\Lambda_1^F = 0$ foreign labor supply is fixed so all changes in employed labor from the steady state balanced growth path are filled by domestic workers. Similarly, if $\Lambda_1^F \alpha^F = 1$, all changes in labor from the steady state balanced growth path are absorbed by foreign labor supply. The starting point for the calibration in all countries is to allow for changes in labor to be absorbed by foreign workers based on the share of foreign labor in total labor in steady state.

In steady state, total remittances sent abroad, PAY_t , are set for 2010–2015 to bilateral remittance payments from Ratha and Shaw (2007). Foreign labor supply and outgoing remittance are set equal to the data. Thus, the relative productivity of foreign workers, z_t^F (and by extension foreign wages, w_t^F), jointly determines the marginal propensity to remit, MPR , and the share of LIQ agents in total consumption. Foreigners' relative productivity, z_t^F , is set to get MPR to match the remittance dynamics from the SVAR, while also assuring a sensible share of LIQ agents in total consumption (based on Andrle and others, 2015). If relative productivity alone is insufficient to replicate the remittance dynamics with the SVAR, Λ_1^F is calibrated to generate the additional remittance dynamics by varying the degree of absorption of changes in aggregate labor by foreign workers.

Due to the lack of data on worker status before and after emigration, the default calibration for all regions is to assume that changes in labor emigration are fully drawn from (return to) the non-labor force participating population. The baseline calibration implies that potential output does not change (for example, from "brain drain") from emigration.

Two shocks in particular summarize the global oil market dynamics. The first is a simultaneous increase in private domestic demand in all regions. In this case, a one percent increase in global real GDP increases the real price of oil by 12-13 percent, given the crude oil price is 55 USD\$ a barrel on average in the data sample. The second is a permanent increase in oil supply in the MENA oil-exporting region. A one percent permanent increase in oil supply reduces the global real price of crude oil permanently by 6.5 percent in FSGM, which is consistent with the SVAR estimates.

Similarly, two structural shocks in FSGM are primarily used to calibrate remittance dynamics. These are permanent increases in total factor productivity and temporary increases in private domestic demand in remitter regions. As per the calibration strategy described above, the marginal propensity to remit and the degree of absorption of foreign labor are set to broadly match the remittance dynamics of the home real GDP shocks in the SVAR using these two shocks. Other aspects of FSGM's calibration are identical to Andrle and others (2015).

Currently, remittances in FSGM are modeled to all countries where remittances represent over 1 percent of GDP. Hence, most economies in Central America, Pacific islands, Central and East Asia, and Southeastern Europe are remitters. The United States, the euro area, Russia and the GCC countries are remitters and hosts of foreign labor. Although other countries remit large amounts in U.S. dollars, they often represent a small share in GDP in the destination economies, and hence are not modeled in this exercise for parsimony. A detailed summary of foreign labor, and inflows and outflows of remittances in FSGM is provided in Appendix 1.

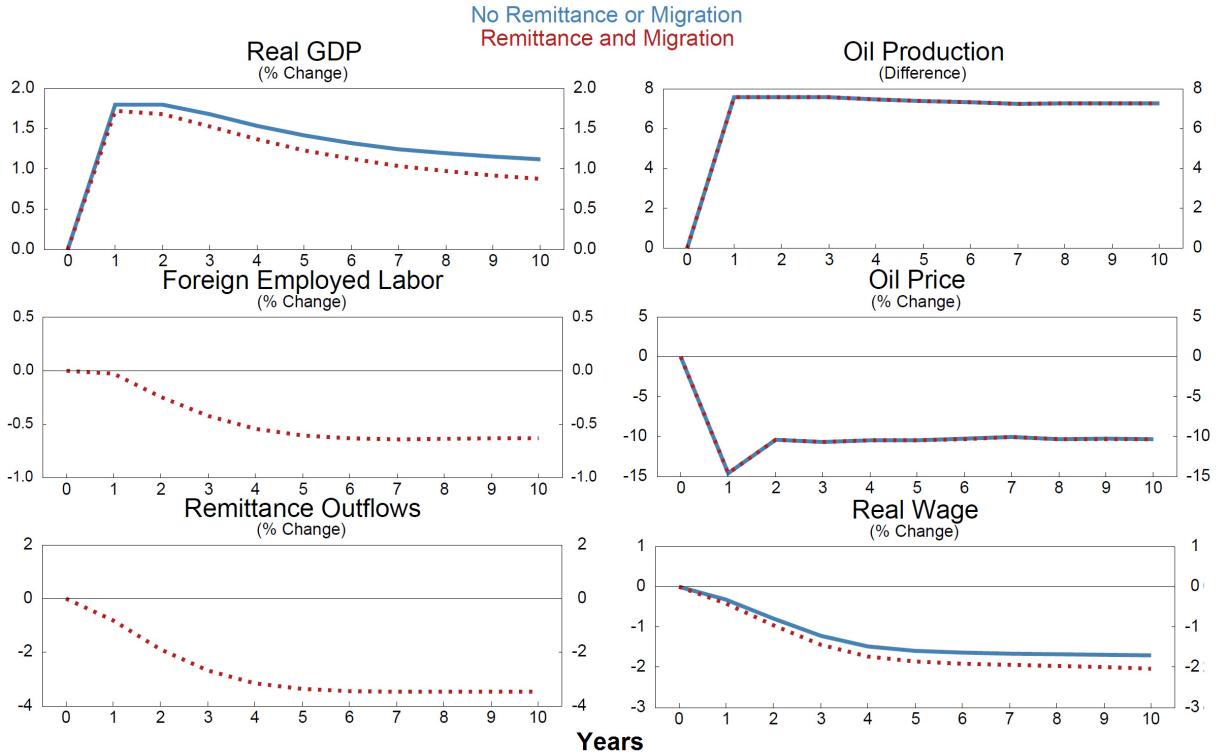
4 Simulation Results

This section illustrates the properties of the proposed model of foreign labor and remittances by examining scenarios pertinent to international remittance flows related to crude oil price movements. Two scenarios are examined, a permanent increase in oil production in the GCC, and a permanent stagnation in output in the euro area.

4.1 Permanent Increase in Oil Production in the GCC

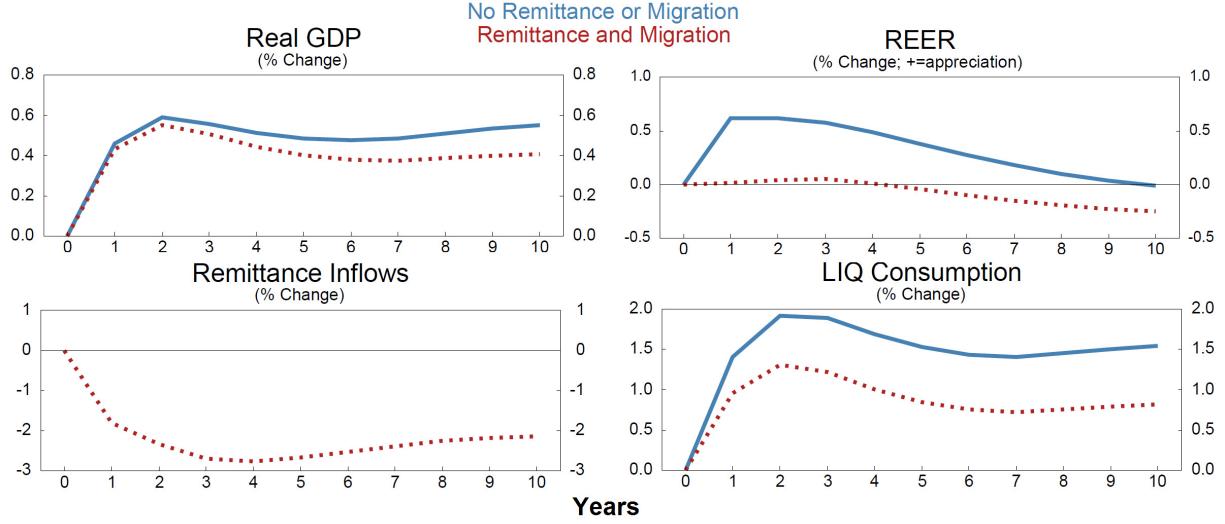
Figure 3 illustrates the effect on the MENA oil-exporting region from a permanent increase in the supply of oil in the GCC countries. The permanent rise in oil supply by close to eight percent results in a 15 percent decline in the real global price of oil in the first year and 10 percent permanent decline thereafter. The fall in oil prices induce a loss in wealth and income of households as royalties from oil production fall, even though there is a rise in real GDP from an increase in real exports and oil production. Overall, the demand for labor and real wages fall, resulting in a four percent permanent decline in remittances and a reduction in the migrant labor stock of 0.6 percent from the MENA oil-exporting region.

Figure 3. MENA Oil Exporters: Permanent Increase in Oil Production in the GCC



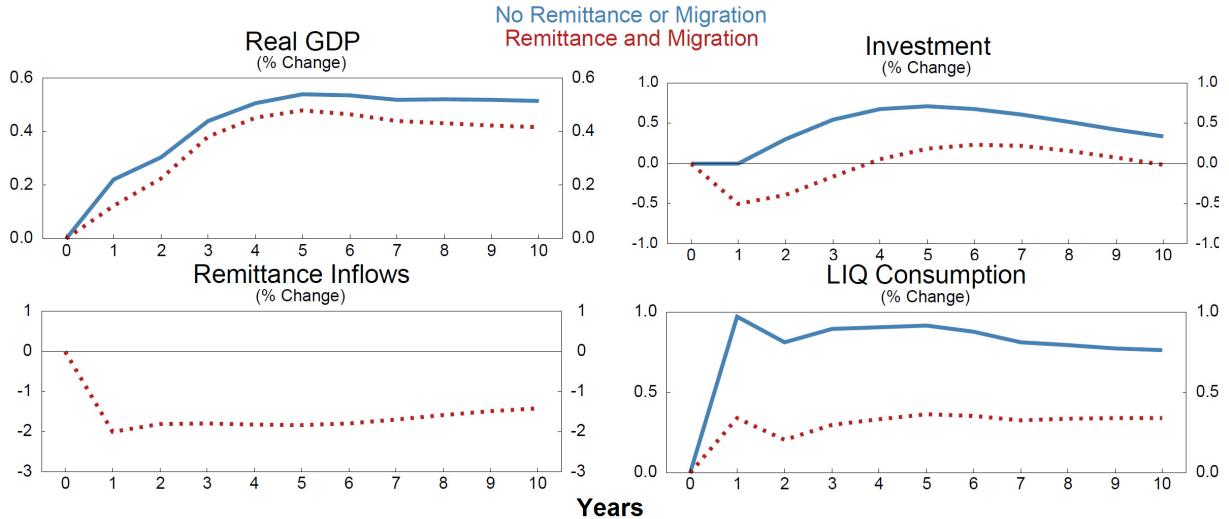
The MENA oil-importing region (Figure 5) experiences close to a three percent decline in remittances at peak which mainly has the effect of lowering LIQ consumption. The decline in remittances from the MENA oil-exporting region are slightly offset by increasing remittances from the euro area and the United States who benefit from the lower oil prices. There is also a increase in

Figure 4. MENA Oil Importers: Permanent Increase in Oil Production in the GCC



return migration to the MENA oil-importing region with the stock of migrants abroad declining by 0.35 percent which only slightly offsets the decline in remittances. While the decline in global real oil prices increase global demand and hence a small increase in the price of metals and agricultural goods, the overall effect from the change in the non-oil primary commodities is small compared to the effect of the decline in real oil prices. As shown by the above example, the macroeconomic effects from movements in real oil prices dominate the macroeconomic effects from remittance, migration, and other non-oil primary commodity channels from oil supply driven crude oil price movements.

Figure 5. CCA Oil Importers: Permanent Increase in Oil Production in the GCC



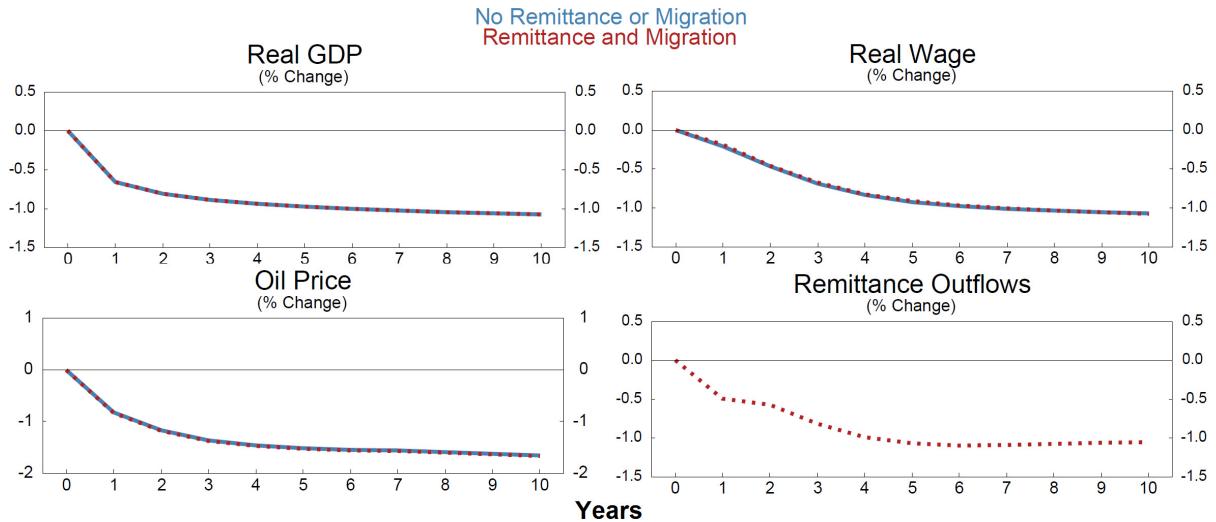
All else equal, the decline in remittance flows has adverse effects on the Central Asia and

Caucasus oil-importing region, which consists of Armenia, Georgia, the Kyrgyz Republic, and Tajikistan (Figure 4). These countries receive almost no remittances from MENA oil exporters, but are highly dependent on remittance flows from Russia with remittance inflows constituting 25 percent of GDP in 2015. The decline in the price of crude oil represents a negative terms of trade and wealth shock to Russia. As oil prices fall, the demand for labor and real wages fall, which induces a three percent decline in remittance outflows from Russia. Remittance inflows to the Central Asia and Caucasus oil-importing region decline by almost two percent. However, as this region is a large oil importer, overall real GDP increases from the improvement in the terms of trade from the falling oil prices. This example illustrates the role of third countries, in this case Russia, on the transmission of remittance flows from oil price shocks. It also illustrates the the role of the remittee's net oil export position, as foreign oil price movements result in lower remittances inflow but also higher real GDP from the improved terms of trade.

4.2 Permanent Stagnation in Output in the Euro Area

Figure 6 presents a permanent stagnation in output driven by a decline in total factor productivity in the euro area that lowers the level of real GDP by one percent in the long run. The decline in the return on capital leads to lower investment which accumulates into a lower capital stock. Reduced marginal product of labor lowers labor demand, and wages decline permanently by one percent. Foreign workers are adversely affected by the 1 percent long run decline in wages and there is a decline in the demand of migrant labor and the stock of migrants by 0.3 percent in the first year. The decline in migrants' labor income and the stock of foreign workers results in a one percent decline in remittance outflows from the euro area.

Figure 6. Euro Area: Economy Wide Productivity Decline in the Euro Area



The decline in euro area productivity transmits to the rest of the world via several channels. The decline in foreign demand reduces the demand for exports of all goods from the Middle East. As global demand declines for all goods, there is a decrease in the demand and prices for all

Figure 7. MENA Oil Importers: Economy Wide Productivity Decline in the Euro Area

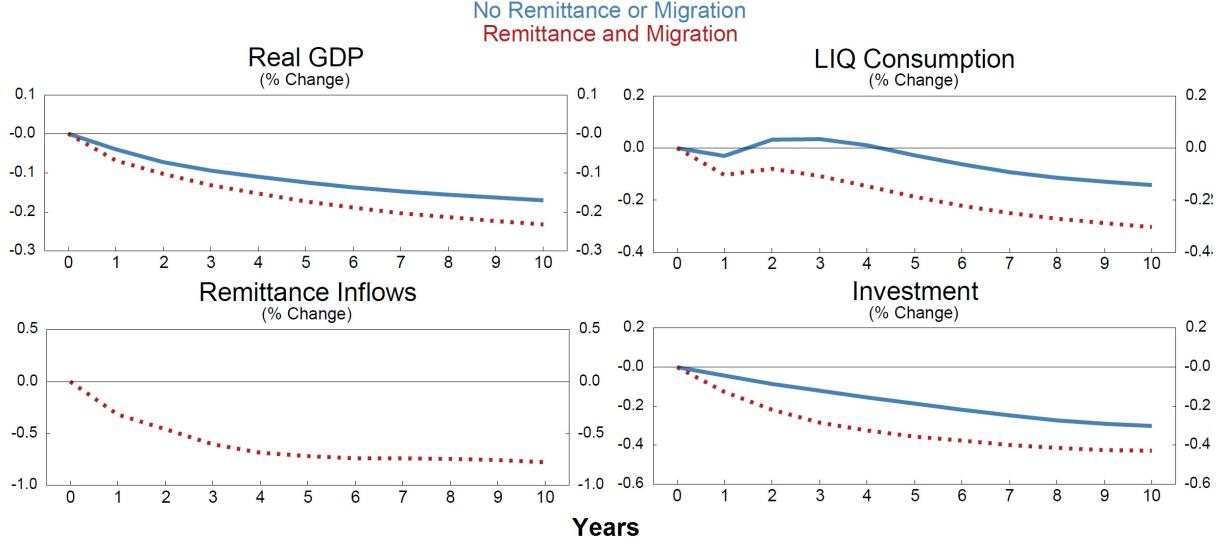
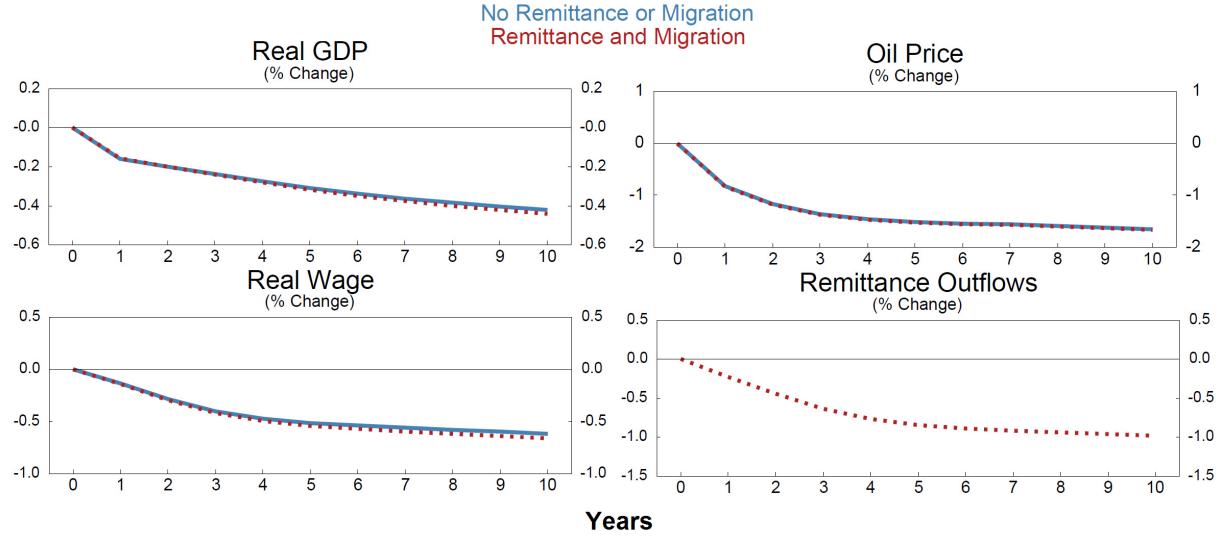


Figure 8. MENA Oil Exporters: Economy Wide Productivity Decline in the Euro Area



commodities. In the long run, real crude oil prices fall by 1.75 percent, real agricultural prices fall by 0.22 percent, and real metals prices fall by 0.62 percent. The Middle East regions are net food importers, with net agricultural imports at 1.6 percent of GDP, so declines in agricultural prices help soften the effect on GDP from the overall decline in foreign demand. The effect from the primary metals market on the Middle east is quite small since both regions are only slight metals exporters. The largest effect from the primary commodity markets is from the decline in oil prices, which has a negative effect on the MENA oil-exporting region, but a positive effect on the MENA oil-importing region.

The MENA oil-importing region is presented in Figure 7. In the model without remittances or

migration, the decline in external demand reduces domestic demand and real GDP in the region. In the model with remittances and migration, the region experiences an overall decline in remittances of close to 0.8 percent in the long run. This leads to an additional 0.2 percent fall in consumption of LIQ households, further reducing domestic demand relative to the model without remittances. The addition of the decline in remittances is slightly offset by the increase return migration with 0.1 percent of total migrants returning home, from the euro area and other regions, which helps support the population and labor force. The effect of return migration is more than off-set by the decline in remittances from abroad.

Interestingly, approximately 75 percent of the decline in remittance inflows to the MENA oil-importing region originates not from the euro area but from the MENA oil-exporting region. As shown in Figure 8, the MENA oil-exporting region is adversely affected by the two percent decline in oil prices and declining external demand from the euro area. Remittance outflows from the MENA oil-exporting region decline by approximately one percent in the long run. As the above example illustrates, remittance inflows from third-party remitter countries may dominate changes in remittance inflows from the country of which the shock originated.

5 Identification of the Motives to Remit and Migrate

The scenario analysis illustrates that remittance inflows and the real GDP of labor-exporting economies can be either negatively or positively correlated depending on the source of the structural disturbance to the global market for crude oil. The correlation of remittance inflows and the real GDP of labor exporting economies are related by the fact that many labor-importing economies are also oil exporters and that many labor-exporting economies are also oil importers. Remittance dynamics from major oil exporters may be driven by commodity price changes that also induce persistent terms of trade effects that have first order effects on the remittee economy. This suggests that, going forward, the link between oil-markets and remittances needs to be made explicit.

The above-mentioned issues also suggest that estimates of conditional correlations of remittances to home economy's GDP cannot be used to draw conclusions on the behavioral motives to remit. Suppose that we allow the marginal propensity to remit to be time varying and dynamically respond to migrants income or conditions in the remittee economy. A range of behavioural specifications, resulting in MPR_t responding in either a positive or negative way to remittee conditions, would not change the correlation of remittances to remittee real GDP. This is because the conditions in the remittee economies are primary driven by terms-of-trade spillovers that dominate the effects from remittance flows. This implies that the correlation of remittee real GDP and remittance flows cannot identify the dynamics of MPR_t or the behavioral incentive to remit. In the same way, estimates of the effect of remittances on aggregate productivity would also need to account for terms of trade changes induced from oil price shocks.

6 Conclusion

This paper provides model-based analysis of international labor migration and remittances induced by shocks to the global market for crude oil. It utilizes a global general equilibrium model with labor migration and remittances in a multilateral setting with endogenous primary commodity markets

for crude oil, metals, and agricultural goods. The multilateral framework shows how changes in remittance inflows need not originate from the region with the underlying economic disturbance but can come primarily through third country effects, such as through international spillovers from global crude oil markets on labor-importing, oil-exporting economies.

The structural DSGE model is calibrated based on a proposed structural empirical method to estimate the dynamics of remittance and labor migration of major remitter regions. The empirical estimates find that the responsiveness of remittance outflows differs across regions and structural shocks. The empirical analysis finds that remittance outflows from Saudi Arabia are more stable than those from Russia, particularly for shocks to home demand and foreign oil supply. Moreover, remittances outflows from domestic demand shocks have a larger elasticity with respect to home real GDP than foreign demand shocks in Russia but the opposite is true for Saudi Arabia.

Structural disturbances to the global market for crude oil are examined in the DSGE model. Results illustrate that remittance inflows and the real GDP of labor-exporting oil-importing economies can be either negatively or positively correlated given shocks to the global market for crude oil. This directly challenges the validity of evaluating alternative theories of remittance behavior based on the responsiveness of remittances to the remitter's GDP. Remittance dynamics from major oil exporters are driven by commodity price changes that can have first order effects on the remittee economies since many labor-exporting economies are also oil-importers.

The results from this paper show why studies on remittances need to take primary commodity and multilateral channels into account. Ignoring shocks to the global market for crude oil as a driver and transmission channel for remittances could bias estimates of remittance behavior or productivity by ignoring large terms of trade effects induced from oil price movements. Further research is needed to decompose remitter dynamics into changes in migration, the marginal propensity to remit, and wages and employment of foreign workers. Such a structural interpretation is crucial for the evaluation of alternative theories of remittance behavior.

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