Behind the Mechanics of International Business Cycles and Remittance Flows

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Abstract

The objective of real business cycle models is to generate a coherent understanding of how and why various aggregate variables co-move. To explain the cyclical pattern of remittances we use a small open economy international real business cycle model that includes a foreign production sector which employs migrants. Independent of migrants' motives to remit, pro- and counter-cyclical patterns can be generated by varying the parameters of the stochastic innovation. Within this framework we show the basic mechanics of remittance flow based on business cycles and labor flows, why it should generally yield negative remittance and domestic output correlations, and why in a broader model it generates negative correlations about 70% of the time. These predictions appear consistent with the empirical literature that frequently finds such negative correlations but also shows why the common interpretation of correlations as implying different motives to remit is inconsistent with the underlying economics.

Introduction

It is common for macroeconomic research to interpret positive correlations between domestic output and remittances as evidence of remitting individuals' motives being investment driven and negative correlations as evidence of altruistic motives. Building on the relatively well established insights from the international business cycle literature, our work makes clear the underlying mechanisms that do drive these correlations. In the process we show that these correlations depend on the business cycle productivity shock structures of the home and host countries and not necessarily on underlying motives.

The real business cycle (RBC) approach to economic fluctuations has been the focus of much attention since it was pioneered by Kydland and Prescott (1982), Long and Plosser (1983), and others in the 1980s. While some of its results concerning the cause of fluctuations continue to be hotly debated, the core notion of viewing aggregate economic variables as the outcomes of decentralizing decisions made by individual households acting to maximize utility subject to production possibilities and resource constraints is the dominant approach today.

Mendoza (1991) expands the application of RBC models to issues prominent in small open economies such as the correlation of savings and investment and the countercyclical pattern of trade. This area of small open economy research has continued to develop and applies RBC models to a range of international issues[1]. Our work contributes to this literature by applying a real business cycle model to address another small open economy issue: what drives remittance flows.

We develop a RBC small open economy model where labor can work at home or abroad. Those working abroad remit home a constant fraction of their earnings. We explore the stochastic properties of output in the home- and host-country industrial sectors to show that whether remittances are pro- or counter-cyclical depend on the relative values of the parameters of these stochastic processes. Our model shows why the

[1] See Finn (1990), which was a predecessor to Mendoza (1991), Schmitt-Grohe and Uribe (2003), Mendoza and Smith (2006), and Garcia-Cicco, Pancrazi and Uribe (2009) to name a few. Another line of open economy work was initiated by Backus, Kehoe, and Kydland (1992, 1995). They study the ability of open economy RBC models to account for various aspects of business cycles not well captured by closed economy models.

correlation between domestic output and foreign remittances is usually negative and under what conditions it turns positive.

An alternative, and somewhat popular, microeconomic approach to explaining remittance flows to understand individual remitters' motives to remit[2]. Divergent views on the motives to remit eventually led to the distinction between remittances being primarily driven by altruistic motives and remittances being driven by investment motives. Even at the microeconomic level this kind of generalization is problematic. As argued by Rapoport and Docquier (2005) "[i]t is not only that different individuals may be heterogeneous in their motivations to remit, but also that different motivations to remit may coexist within the same individual." Despite this problem, some macroeconomic research has decided to interpret remittances that are either pro- or counter-cyclical with home GDP as evidence of either investment or altruistic motives, respectively[3].

Chami, Barajas, Cosimano, Fullenkamp, Gapen and Montiel (2008) have argued that the motivations approach hasn't generated empirically distinguishable hypotheses nor has it generated clear implications for the economic impact of remittances. They propose focusing instead on "the most important distinction among theories from the perspective of economic impact: whether remittances are predominantly compensatory or opportunistic in nature" (Chami et al, 2008). While this is a reasonable approach, it too is running aground on mixed empirical results. Chami, Fullenkamp and Jahjah (2005) have found some of the strongest evidence to date that remittances are better described as compensatory transfers than as opportunistic ones. Work by Frankel (2011) also found them counter-cyclical. Neagu and Schiff (2009) found that remittances are pro-cyclical. And, Durdu and Sayan (2008) found them counter-cyclical in Mexico but pro-cyclical in Turkey. Thus, motives have been found to differ by country and/or empirical metric.

In our view, a change is required in the thinking on the cyclicality of remittances. Real business cycle models provide fertile intellectual ground for thinking clearly about remittance flows and their cyclicality. To paraphrase Plosser (1989), the objective of RBC models is to generate a coherent understanding of how and why co-movement

[2] Lucas and Stark (1985) is one of the early treatments of the topic upon which much later work is built. See Rapoport and Docquier (2005) and Chami, et al (2008) for excellent reviews of this entire literature at both the micro and macro level.

[3] Higgins, Matthew L., Alketa Hysenbegaszi, and Susan Pozo (2004) for example find support for investment motives based on macroeconomic correlations of remittances and domestic GDP.

among economic activities arise. The appeal of RBC models is that they do this successfully based on very simple economic principles and yet generate dynamic behavior that was initially thought to be incompatible with any notion of equilibrium. We believe RBC models can shine a similar light on the issue of remittances and their cyclicality.

We develop such model with a domestic and foreign labor market that includes remittances from workers in the foreign market. We explore the stochastic properties of output in the home- and host-country industrial sectors to show that whether remittances are pro- or counter-cyclical depend on the relative values of the parameters of these stochastic processes. In this regard we follow the approach of Finn (1990) in assuming two countries' processes can be interrelated and using the associated calibrated model to shed light on a contentious topic in the open economy literature. Finn (1990) did this to explain the relationship between savings and investment in a small open economy and we do this to explain the cyclicality of remittances.

Our model shows why the correlation between domestic output and foreign remittances is usually negative. We further show the conditions under which the correlation turns positive and find that, if we assume country parameters are uniformly distributed across countries, then we should still observe negative correlations about 70% of the time. This helps explain why the majority of empirical investigations continue to find negative correlations in the specific country data. Finally, since we can generate positive and negative correlations by means of a mechanism (i.e., RBCs) that has been widely accepted in economic research for several decades now and which follows basic economic intuition without ever changing the underlying preferences or "motivation" of individual remitters, our work argues against most of the work found in the motivation literature, at least at the macroeconomic level.

1. The Model

1.1. Representative Households

Households are endowed with a stock of labor/leisure time that is constant and normalized to unity. At each point in time the household can allocate labor to the domestic labor market, h, the foreign labor market, h_f, or to neither labor market, L, otherwise known as leisure. The labor constraint is

$$(1.1)\quad 1 = L_t + h_t + h_{f,t}.$$

Households have well defined utility over the consumption services of a single traded good, c, labor services, h and h_f, and have a constant subjective rate of time preference, β,

$$(1.2)\quad E_t\left\{\sum_{t=0}^{\infty}\beta^t\left[\log(c_t) + Dh_t + D_{f,t}h_{f,t}\right]\right\}.$$

where D and D_f are negative constants. This formulation follows Hansen's (1985) for indivisible labor[4]. Assuming indivisible labor allows an analytically tractable modeling approach while also capturing relevant macroeconomic dynamics in the labor market.

Households face the following real flow budget constraint

$$(1.3)\quad b_t + k_t + c_t = Rw_{f,t}h_{f,t} + w_t h_t + r_t k_{t-1} + (1-\delta)k_{t-1} - \frac{\kappa}{2}(k_t - k_{t-1})^2 + (1 + r_{b,t-1})b_{t-1}$$

which says that individuals earn or pay a real return, r_b, on internationally traded bond holdings (denominated in traded goods), b, earn real wages, w, on labor supplied to the domestic market, h, real wages, w_f, on labor supplied to the foreign labor market, h_f, a constant fraction R of which is remitted home, and earn a return, r, on capital, k, which depreciates at rate, δ, and is accumulated at quadratic cost, $\frac{\kappa}{2}(k_t - k_{t-1})^2$. Out of their earnings, households finance consumption, c, add to their capital stock, k, and buy new foreign bonds, b. The model doesn't include the fraction *1-R* that isn't remitted home. This amount is thought of as the financial cost of migrating and living abroad.

To ensure stationarity without altering the equilibrium dynamics at business cycle frequencies we follow Schmitt-Grohe and Uribe (2003) in assuming an upward sloping supply curve for international funds[5]. We use the following formulation from McCandless (2008),

$$(1.4)\quad r_{b,t} = r^w - xB_t.$$

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[4] See appendix for a note on reinterpreting Hansen's formulation when there are two labor markets.

[5] Small open economy models display steady states that depend on initial conditions causing transient shocks to have long-run effects and making techniques, like those used with DSGE models, based on local behavior around a given steady state generally inapplicable. An upward sloping supply curve solves this problem. See Schmitt-Grohe and Uribe (2003) for a more complete discussion of the topic.

Here r^w is the constant world real interest rate, x is a positive parameter, and B_t reflects the aggregate level of borrowing in the domestic economy. Since we have a representative household, aggregate borrowing equals individual borrowing, $b_t = B_t$.

1.2. Firms

There are two identical sectors, both perfectly competitive in their input and output markets. The first is domestic and uses only one input – domestically supplied labor. Profits for the representative domestic firm are

(1.5) $\pi_t = A_t k_{t-1}^{\theta} h_t^{1-\theta} - w_t h_t - r_t k_{t-1} = 0$

where A represents technology and is stochastic, defined below. Production depends on labor and domestic capital. The final equality with zero reflects the perfectly competitive nature of the output market. This sector produces an internationally traded consumption good.

The other sector is in the foreign country, uses immigrant labor and foreign capital. Profits for the representative foreign firm are

(1.6) $\pi_{f\,t} = A_{f,t} k_f^{\theta} h_{f,t}^{1-\theta} - w_{f,t} h_{f,t} - r_{f,t} k_{f,t-1} = 0$

where all variables and equalities here have the same interpretation as in the domestic sectors, but are subscripted with "f" to denote the foreign sector. This sector produces the same internationally traded good. The foreign macro economy is not modeled explicitly, so k_f is assumed constant but not removed for calibration purposes. Hence this is still a model of a small open home economy.

The processes A and A_f are stochastic and defined as

(1.7) $$\begin{pmatrix} A_t \\ A_{f,t} \end{pmatrix} = \begin{pmatrix} \gamma_1 & \gamma_2 \\ \gamma_{f1} & \gamma_{f2} \end{pmatrix} \begin{pmatrix} A_{t-1} \\ A_{f,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \varepsilon_{f,t} \end{pmatrix}$$

where $E_t\{\varepsilon_t\} = E_t\{\varepsilon_{f,t}\} = 0$, $E_t\{\varepsilon_t \varepsilon_s\} = \sigma_\varepsilon^2 \;\forall t = s$ and 0 otherwise, $E_t\{\varepsilon_{f,t}\varepsilon_{f,s}\} = \sigma_f^2 \;\forall t = s$ and 0 otherwise, and finally, $E_t\{\varepsilon_t \varepsilon_{f,t}\} = \varphi \sigma_\varepsilon \sigma_f \;\forall t = s$ and 0 otherwise. This formulation allows the business cycles to influence each other. Our main results hold (although exact values change) as long as $\gamma_2 > \gamma_{f1}$. We generally consider only the case of $\gamma_{f1}=0$ since we are primarily interested in worlds where the large open economy influences small open economies, but not the other way around.

Profit maximization yields the following results,

(1.8) $r_t = \theta A_t k_{t-1}^{\theta-1} h_t^{1-\theta}$,

(1.9) $w_t = (1-\theta) A_t k_{t-1}^{\theta} h_t^{-\theta}$,

(1.10) $w_{f,t} = (1-\theta) A_{f,t} \bar{k}_f^{\theta} h_{f,t}^{-\theta}$,

which are the standard results relating marginal products with marginal costs.

2. Characterizing the Solution

Households maximize (1.2) subject to (1.3) and taking (1.4), w, w_f, r, and r_b as given[6]. Rearranging and combining optimality conditions yields the familiar Lucas asset pricing equation. That is, the Euler equation relating consumption over time and the interest rate on borrowing/lending, r_{bt},

(2.1) $1 = \beta E_t \dfrac{c_t}{c_{t+1}} (1 + r_{b,t})$.

Since $r_{b,t} \left(= r^w - xB_t\right)$ depends on the aggregate stock of international debt, households take it as given when making their individual consumption smoothing decisions but are jointly determining the interest rate.

There is an additional Euler equation relating consumption over time and the return on capital, r_t,

(2.2) $\left(1 + \kappa(k_t - k_{t-1})\right) = \beta E_t \dfrac{c_t}{c_{t+1}} \left[r_{t+1} + (1-\delta) + \kappa(k_{t+1} - k_t)\right]$.

In steady state, the capital adjustment cost components are zero and these equations, (2.1) and (2.2), equate the return on capital, $r_{t+1} + (1-\delta)$, with the return on international assets, r_{bt}, which is the no-arbitrage condition in the asset market for this economy.

The unique feature of this model is that households can allocate their labor to either domestic or foreign markets. From the household's optimality conditions we obtain

6 Details on solving the Lagrangian and deriving the relevant optimality conditions are included in the mathematical appendix.

(2.3) $D = -\frac{w_t}{c_t}$,

and

(2.4) $D_f = -\frac{Rw_{f,t}}{c_t}$.

Since labor is free to move between markets, we obtain the following no-arbitrage labor market condition,

(2.5) $w_t = \left(\frac{D}{D_f}\right) Rw_{f,t}$.

This says that the domestic wage must equal the foreign wage times the fraction remitted and the ratio of (dis)utility weights D and D_f. A useful feature of this formulation is that the wages themselves do not have to equate across countries, but the total earnings received by the domestic, representative households do.

The equilibrium of the model is fully characterized by a system of 11 variables (c, w, w_f, h, h_f, r_b, b, r, k, A, and A_f) and 11 equations – the budget constraint, (1.3), the firms' optimality conditions (1.8) – (1.10), the household's optimality conditions (2.1) – (2.4), the equation for the supply of international funds, (1.4), and the 2 stochastic processes, (1.7).

3. Why We Generally Observe Negative Correlations

Before proceeding to stochastic simulations, it is useful to consider two conceptual experiments that help clarify the intuition behind our final results. We do this by examining a world where the stochastic processes in each country are unrelated. That is $\gamma_2 = \gamma_{f1} = 0$ in equations (1.7). This allows us to focus solely on the effects coming from labor movements.

Consider the case of a permanent increase in A, a positive technological shock at home. On impact, by (1.9), w increases given the initial stock of labor. This attracts labor to the domestic sector, raising h and lowering h_f. These adjustments lower w and raise w_f until they are equal through (2.5) again, both at levels higher than their initial level.

Since remittances in this economy are defined by $Rw_f h_f$, and R is constant, the change in remittances depends on the elasticity of labor demand in the foreign sector. Remittances will decrease if the absolute value wage elasticity of labor demand is greater than unity,

(3.1) $$\frac{w_{f,t}}{h_{f,t}}\frac{dh_{f,t}}{dw_{f,t}} = \left|\frac{w_{f,t}}{h_{f,t}}\frac{1}{A_{f,t}\theta(\theta-1)k_f^{\theta}h_{f,t}^{-1-\theta}}\right| > 1 \ .$$

Hence, remittances decrease in response to a domestic economic boom. Although wages increased in the foreign sector, there is less labor employed there and total foreign earnings decline. Empirically this is a negative relationship between domestic output and remittances following such a shock. Finally, note that the increase in domestic wages is a negative supply shock for the foreign sector since it decreases the amount of labor supplied in that sector by attracting labor to the home market.

Analogous reasoning shows that an increase in the foreign technology, A_f, increases wages in both countries but reallocates labor into the foreign and out of the domestic economy. Remittances must increase in this case since both the quantity of labor and the wages paid in the foreign sector increase. This comes in part from attracting labor away from the domestic economy and thus generates a decline in domestic output. Once again, a negative relationship between domestic output and remittances emerges.

These conceptual experiments show that, for economies with independent shock structures, remittances and domestic output are always negatively related. In the first case, the foreign market receives a negative supply shock. The change in total earnings then depends entirely upon the elasticity of the labor demand curve in the foreign market. In our model, and all models with Cobb-Douglas production functions[7], foreign sector labor demand is sufficiently elastic so that negative shocks in the foreign labor market always generate a decline in total earnings (and hence remittances) and positive shocks, an increase. Since negative shocks in the foreign country are coming from positive shocks at home, a counter-cyclical remittance pattern emerges.

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7 $\left|\frac{w_{f,t}}{h_{f,t}}\frac{1}{A_{f,t}\theta(\theta-1)k_f^{\theta}h_{f,t}^{-1-\theta}}\right| = \left|\frac{1}{-\theta}\right| = \frac{1}{\theta} > 1 \Leftrightarrow \theta > 0$, which is assumed.

In the second case, there is a positive demand shock in the foreign economy. Here elasticity is not an issue. Remittances/total earnings increase with positive shocks and decrease with negative ones in the foreign labor market. The counter cyclical remittance pattern still emerges because an increase in foreign demand is a negative supply shock in the home market and thus lowers output.

This core mechanism remains at work throughout the paper. This mechanism helps explain why empirically we generally observe negative correlations since the fundamental mechanism generates them. Only deviations from it should result in positive correlations. It also challenges researchers to explain why we would ever observe pro-cyclical remittance flows.

4. Correlated Cycles and Remittance Flows: Simulation Results

Suppose now that the economies' business cycles can depend on each other in the sense of Finn (1990) and Backus, Kehoe, and Kydland (1992, 1995). To keep matters tractable and focused on small open economies, we will assume throughout that the domestic economy's shocks do not affect the foreign economy's shocks directly (i.e., $\gamma_{1f} = 0$)[8]. We simulate the basic model and produce impulse response functions (IRFs)[9]. The length of time is set to one quarter.

4.1 Independent Economies and the Basic Mechanism

The model is first parameterized to simulate the basic mechanism discussed analytically in section 3. γ_2 in (1.7) is set to zero so that the economies are independent of each other. γ_1 and γ_{f2} in (1.7) are both set to 0.8 for symmetry[10]. With $\gamma_2 = 0$ the

[8] Copies of our results where this assumption is dropped can be obtained from the authors upon request. Dropping the assumption complicates the story and interpretation, but it does not alter our findings and only strengthens our point that business cycles, not different motives, are driving observed remittance flow patterns.

[9] All Dynare and related Matlab code is available upon request from the authors. Dynare itself can be downloaded at: http://www.cepremap.cnrs.fr/dynare/

[10] Backus, Kehoe, and Kydland (1992) estimte this parameter as .906 for the US and Europe. Garcia-Cicco, Pancrazi and Uribe (2010) estimate a median value of .765 in standard RBC models for Argentina and Mexico. We have chosen an initial value between these since we are generally thinking of one country being an emerging and the other a developed economy but wanted to begin with a symmetrical case for illustrative purposes.

correlation of interest is always negative. We need only increase γ_2 to generate correlation reversals (i.e., pro-cyclical patterns), which we do in the next section.

$$\begin{pmatrix} A_t \\ A_{f,t} \end{pmatrix} = \begin{pmatrix} 0.8 & 0 \\ 0 & 0.8 \end{pmatrix} \begin{pmatrix} A_{t-1} \\ A_{f,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \varepsilon_{f,t} \end{pmatrix}$$

This allows the rest of the model parameters to remain unchanged across experiments. Later we show results from a grid search over all possible parameter combinations.

Figure 1 presents the IRFs for a one standard deviation shock to domestic technology. The initial innovation in technology is shown in panel "A". The effect of this is to raise demand for labor in the domestic market which increases the domestic wage (panel "w") and the number of hours devoted to labor at home (panel "h"). The increase in productivity (panel "A") and the increase in labor supplied (panel "h") mean that the marginal product of capital has also increased at home (panel "r"), thus increasing the stock of capital over time (panel "k"). Since technology, labor and capital have all increased domestically, so must output (panel "y"). Higher output implies higher consumption as well (panel "c"). Since the increase in output comes from an initial jump and then continues to rise over time before slowing it's rate of increase (see panel "y"), consumption initially increases by more than the initial increase in income, as is typical in rational forward-looking models. To finance the additional consumption and additional capital accumulation, domestic households borrow from world markets (panel "b"). Each household's debt accumulation implies that aggregate debt also increases (i.e., the decline in b in panel "b") which initially raises the interest rate charged to this country due to the upward sloping supply of funds. It's these interest rate changes that temper the increase in debt and accumulation of capital and return the economy to steady state.[11]

The higher domestic wage attracts workers away from the foreign market (seen in panel "hf") which lowers the supply of labor in that market and raises the wage (panel "wf"). Because labor demand in the foreign sector is elastic, the combined effect is that remittances decline (panel "remit"). This, combined with panel "y" produces the counter-cyclical pattern resulting from the basic mechanism. In this example, the correlation

[11] This is how the upward sloping supply curve assumption ensures stationarity (Schmitt-Grohe and Uribe, 2003).

between remittances and domestic output is -0.5251. It is also interesting to note that the correlation for the series of borrowing, *b*, and remittances is -0.3839 in this basic parameterization.

Figure 2 shows analogous results for a shock to the foreign sector. The key differences from Figure 1 are that the shock in the foreign sector (panel "Af") raises foreign wages (panel "wf") thereby attracting labor out of the domestic sector (panel "h") and into the foreign sector (panel "hf"). The increase in labor and wages in the foreign sector means that remittances increase (panel "remit"). But since they are being pulled from the domestic sector (panel "h"), this generates a decline in domestic output (panel "y") again generating a counter-cyclical pattern. Note also that the decline in domestic labor usage lowers the marginal productivity of capital (panel "r") resulting in a decline in capital accumulation domestically (panel "k").

Here the correlation between remittances and domestic output is still negative (-0.7381) but due to an increase in remittances and a decline in domestic output which is the exact opposite of the reason in Figure 1. The correlation of borrowing (panel "b") and remittances is 0.9406 which is a little surprising at first glance since consumption increased (panel "c") but output fell (panel "y"). This is because increased remittances represent an increase in overall income for domestic households. The extra income (combined with less capital accumulation) is temporary but sufficiently long lasting both to finance the increase in consumption and an increase in lending in world markets (panel "b") which lowers the rate paid (panel "rf") since aggregate debt falls.

These first two cases primarily confirm the results of the basic mechanism at work. They have empirical implications in that the independent economy assumption likely fits many real world scenarios when there is not an obvious single large foreign partner for the small open economy. In these cases, the dominant prediction is that remittances will be counter-cyclical with domestic output although the reason is entirely independent of motives. It is a result of demand elasticity for migrant labor in the foreign labor market.

4.2 Dependent Economies and Correlation Reversals

The only difference between these simulations and the ones of section 4.1 is that shocks to the foreign economy's technology are allowed to affect the domestic economy. All other parameters are the same, but $\gamma_2 = 0.10$, a seemingly small change,

$$\begin{pmatrix} A_t \\ A_{f,t} \end{pmatrix} = \begin{pmatrix} 0.8 & 0.10 \\ 0 & 0.8 \end{pmatrix} \begin{pmatrix} A_{t-1} \\ A_{f,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \varepsilon_{f,t} \end{pmatrix}.$$

Again, the exact value is somewhat arbitrary but not out of line with international estimates and we report a full grid search later.

Since γ_{f2} is still at zero, innovations in the domestic technology process are not passed to the foreign sector which reflects our small open economy assumption for the home economy. As a result the results for a domestic shock is identical to the results for the independent economies in Figure 1. An initial lesson from this is that having cross-country effects doesn't necessarily generate correlation reversals, especially if they are largely uni-directional. We will see later, however, that there is actually a wide range of parameter values for which remittances are counter-cyclical but a non-trivial range for which they are pro-cylical. Cross-country effects are thus necessary but not sufficient to generate correlation reversals.

Figure 3 presents the results for a shock to foreign productivity. The impact effect is the same as that in Figure 2 since the cross-country effects occur with a lag only. Upon impact then there is a decline in domestic output (panel "y") and an increase in remittances (panel "remit"). The key difference, and the reason for the correlation's sign reversal in this case, is that the technology boom in the foreign market gets passed to the domestic market in subsequent periods, soon leading to a similar boom at home as well (panels
"Af" and "A", respectively). This alone causes an increase in domestic output in later periods which then tapers off and oscillates towards its steady state level (panel "y"). This means that there is a substantial portion of the sequence of the domestic output series for which domestic output (panel "y") and remittances (panel "remit) are simultaneously growing. Within these two panels we actually observe periods of pro- and counter-cyclical remittance patterns. Calculating the correlation takes the entirety of both series into account and is here 0.0627. Statistically, then, one would find remittances to be pro-cyclical over the whole period. The key result is that a

modification of parameter values in a model of business cycles at home and abroad drives pro- and counter-cyclical patterns without resorting to ad hoc assumptions of non-constant preferences and/or alternating "motives", in the terminology of the remittances literature.

4.3. Parameter Grid Search and Regions of Correlation Reversals

The previous experiments show that there does exist at least one parameterization for which correlations of remittances and domestic output switch from negative to positive. The real issue, however, is what the general relationship between the various parameters and the correlation looks like. To address this we search over each parameter γ_1 and γ_{f2} from 0.05 to 0.95 and γ_2 from 0.0 to 0.95, all in step increments of 0.05. The cross-country parameter, γ_2, is allowed to take on the value of zero in order to include the case of independent economies. For each combination, the full simulation was run and the correlation of remittances and domestic output was calculated, yielding a total of 6480 correlation observations.

Figure 4 (a) and (b) present the correlation surface for various γ_1 and γ_2 combinations, given γ_{f2}. Intuitively, we are thinking of a world with a given large open economy like the US (or the EU) and a number of small open economies that are connected to the large economy via its migrant labor supply. The large economy will have an associated and unvarying γ_{f2}. The small open economies will likely vary in terms of domestic cyclical patterns, nearness and openness to the large economy and so on. Thus any correlation differences between remittances and domestic output must be coming from the parameter combinations in the small open economies, not from the single large economy. For this reason, Figures 4 report surfaces over all combinations of domestic small open economy parameters (i.e., γ_1 and γ_2) while holding the large economy parameter, γ_{f2} constant. The upper and lower boundaries for the γ_{f2} come from Schmitt-Grohe and Uribe (2003) which uses $\gamma_{f2} = 0.4$ (upper left panel in Figures 4)[12] and McCandless (2008) which uses a value of $\gamma_{f2} = 0.95$ (bottom right panel). The two intermediate graphs report surfaces for $\gamma_{f2} = 0.5$ (upper left panel) and $\gamma_{f2} = 0.65$ (bottom

[12] Schmitt-Grohe and Uribe (2003) actually use 0.42, but our values are in increments of 0.05 and thus we round down to 0.4.

left panel) which are the average γ_{f2} in our simulation (which runs from 0.5 to 0.95) and the average of the upper and lower boundaries from the literature (i.e., 0.4 and 0.95), respectively. This gives some feel for the range of possibilities given γ_{f2}.

Two key results follow from these figures. First, given the large economy's cycle, there exist a range of domestic parameterizations that generate both negative (counter-cyclical) and positive (pro-cyclical) patterns. And, second, given the large economy's cycle, much more of the surface is associated with negative than with positive correlations. Thus, if parameters were uniformly and randomly distributed in the world, then we would expect to find remittances more generally counter- than pro-cyclical, which is consistent with most empirical studies[13].

Figure 5 presents a histogram of the correlations for all values of all parameters (i.e., not holding γ_{f2} constant). Consistent with the conclusions drawn from Figure 4, the majority of the combinations yield a negative correlation. Table 1 breaks the results into combinations yielding only positive correlations and those yielding only negative correlations. This reveals that 4651, or 71.8%, of the 6480 combinations yield a negative correlation. Only 324 (or 5% of the total) combinations are for independent economies, which must yield negative correlations. Thus, 66.8% of the combinations are of economies with some cross-country effects and negative correlations. This confirms the suggestion that we should observe negative correlations most of the time (71.8% of the time). Additionally, this holds for independent and dependent economies and thus a positive cross-country parameter is necessary but not sufficient to generate a pro-cyclical pattern. This is generally consistent with other empirical results such as Sayan (2006) who finds in a panel of 12 countries that remittances are countercyclical in aggregate, but can be pro-cyclical at the individual country level. Frenkel (2011) who better controls for host-country cycles finds a similar result.

Table 1 also shows that the largest (absolute value) negative correlation is -0.715 and the largest positive correlation is 0.615. The average negative is -0.304 and positive is 0.187. In absolute terms the largest and average negative exceed the largest and average positive correlations, again suggesting that the negative correlation is a stronger result than the positive.

[13] A good recent example is Frankel (2011).

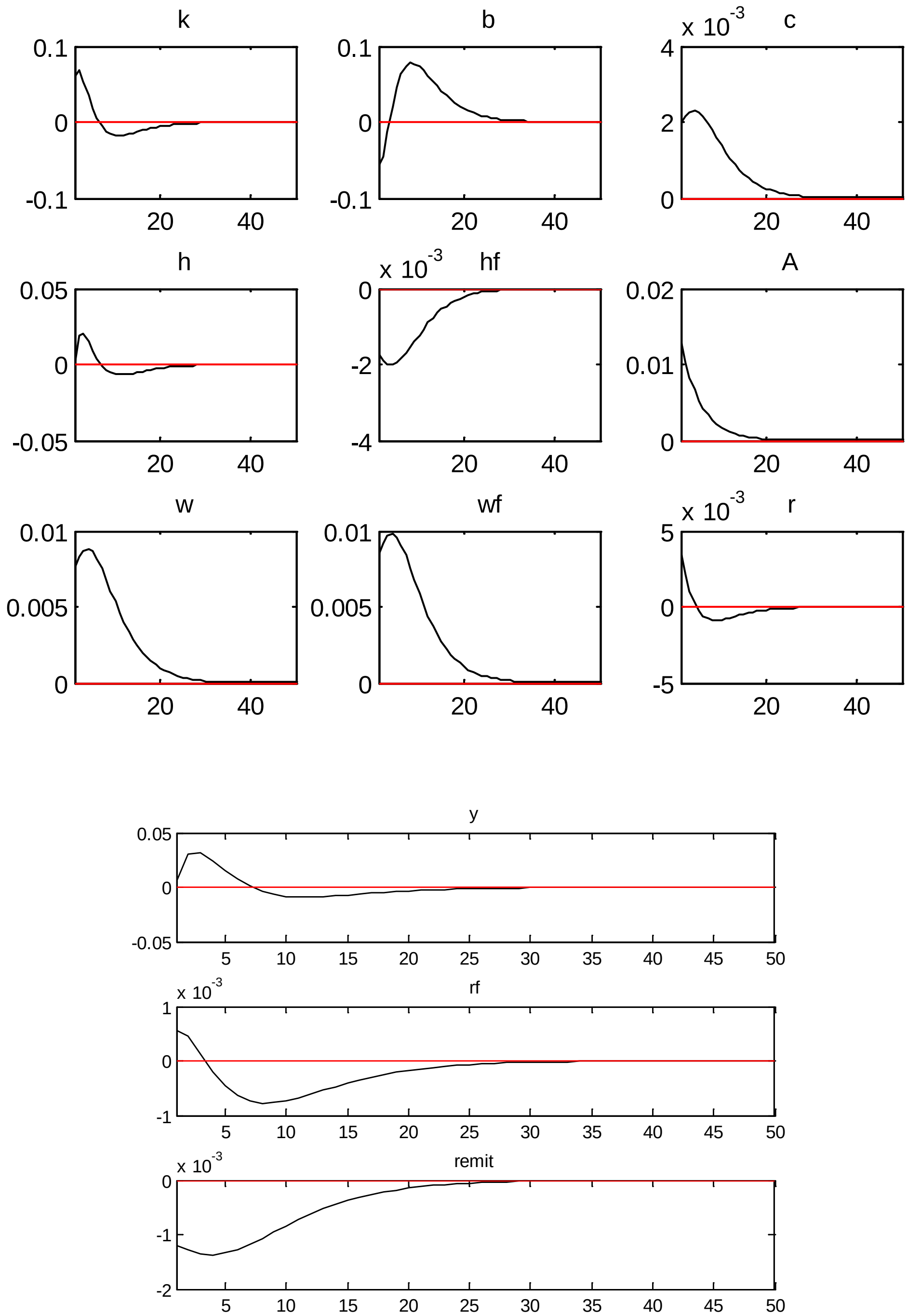
In general, when the domestic technology process drives the results (i.e., when γ_1 is large) then the basic mechanism is dominant and the correlations are mostly negative. This can be seen in Table 1 since the average value of γ_1 for negative correlations (0.629) is larger than the average for positive correlations (0.251). This also true for the γ_1's associated with the maximum negative correlation (0.95) relative to the $\gamma 1$ for the maximum positive correlation (0.05). This general pattern is also borne out in Figure 6 which is a plot of the values of γ_1 associated with the minimum and maximum correlations. There are a wide range of values for γ_1 associated with negative correlations but positive correlations are more likely to be observed only when γ_1 is relatively small, all else equal.

The opposite is true of γ_2 as seen in Figure 7. This plot shows that, while a range of γ_2's are consistent with negative correlations, positive correlations are more likely to be observed the larger is γ_2, all else equal. Intuitively, there needs to be a large cross-country effect where foreign shocks can influence the domestic economy in order to reverse the sign of the correlation. There are a range of γ_{f2} values consistent with either negative or positive correlations as seen in Figure 8. Nevertheless, the negative region dominates and positive correlations are more likely for larger but intermediary values of γ_{f2}. At one level this is because, given the foreign technology's innovation, correlation reversal depends on the domestic shocks, γ_1, and how much of the foreign shock is passed through to the domestic country, γ_2. At another level, that the maximum likelihood that positive correlations are associated with intermediate values suggests that too strong and persistent a foreign shock (say, combined with small pass through, γ_2) might also generate dynamics similar to the basic mechanism whereas intermediate values, even with a small pass through, keep the basic mechanism dampened.

6. Conclusions

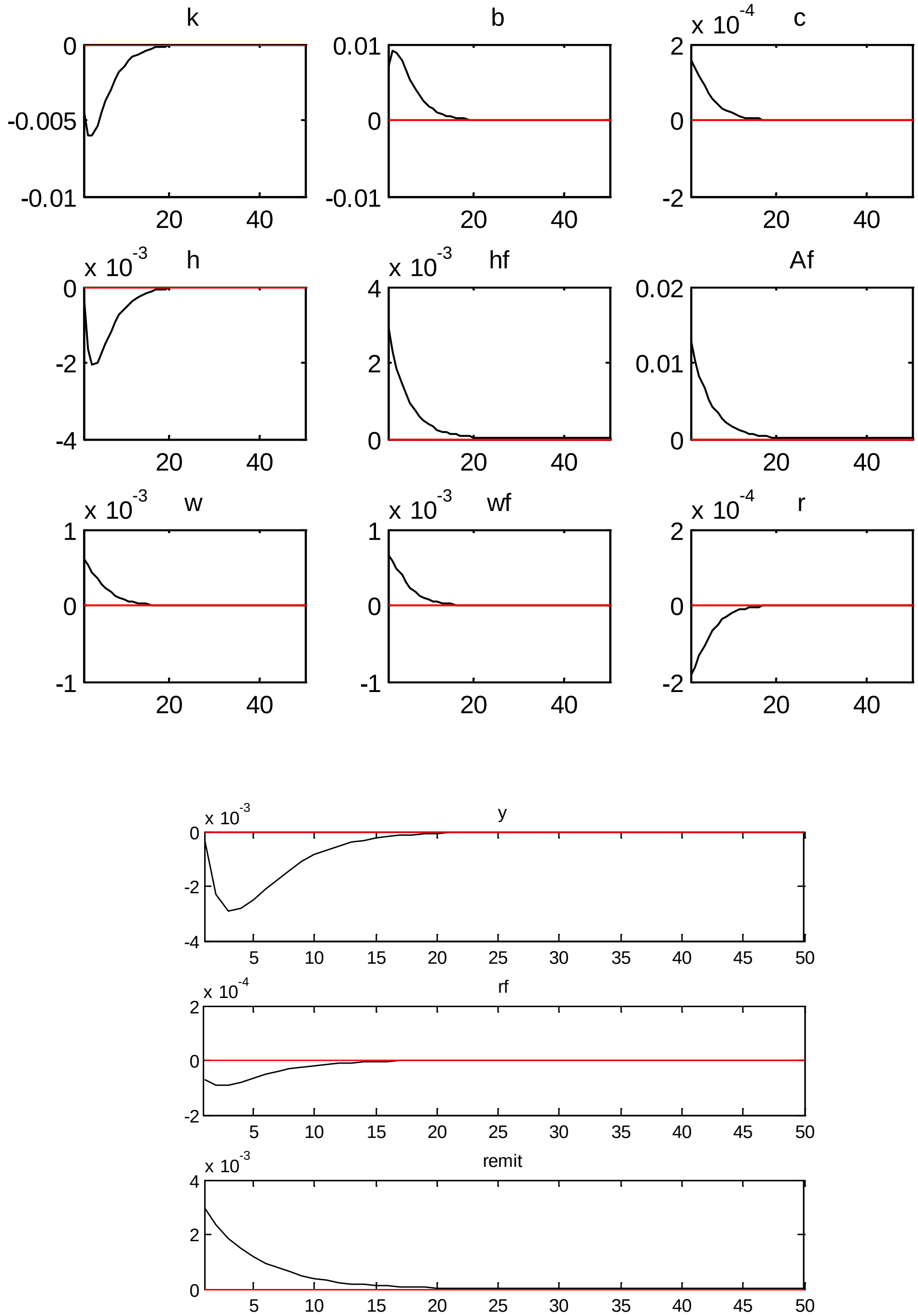
The macroeconomic importance of remittances is still poorly understood but gaining increasing attention from policy makers and researchers alike. Our macro knowledge builds on past micro work, some of which focused on the motivations to remit. While motives in this sense do not logically aggregate to the macro level, many researchers have continued to interpret correlations between domestic output and remittances as evidence of the underlying motives of migrants to remit for altruistic and for opportunistic reasons. This paper has shown that a basic real business cycle approach to this question bears a great deal more fruit and quantitative predictions. In particular, by allowing economies to be connected along the lines of Backus, Kehoe, and Kydland (1992 and 1995) as well as many others in the small open economy RBC literature, one can easily generate a range of positive and negative correlation patterns by varying RBC-related parameters without any reference to changing motives. The model shows that countries with cross country business cycle pass through and relatively low domestic business cycle serial correlation are more likely to experience positive correlations (pro-cyclical remittance flows) than those with high serial correlation and lower cross country pass through.

Figure 1: IRFs for Shock to Domestic Productivity – Independent and Dependent Economies



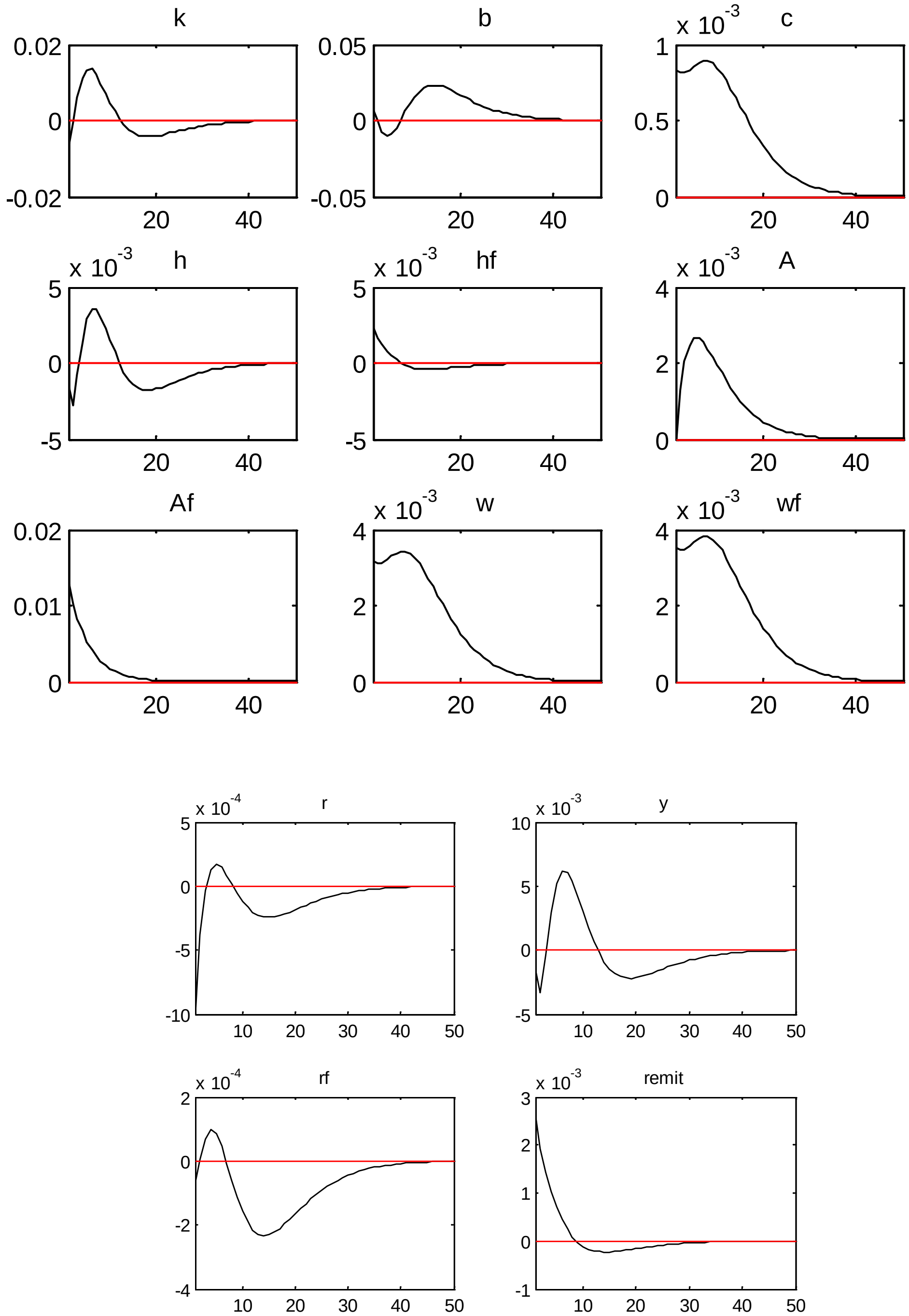
Note: Generated by Dynare for a one standard deviation shock to ε_t. Parameters: $\gamma_1 = 0.8$, $\gamma_2 = 0$, $\gamma_{f1}=0$, and $\gamma_{f2} = 0.8$. Correlations: corr(remit_eps,y_eps) = -0.5251, corr(remit_eps,b_eps) = -0.3839.

Figure 2: IRFs for Shock to Foreign Productivity – Independent Economies



Note: Generated by Dynare for a one standard deviation shock to ε_t. Parameters: $\gamma_1 = 0.8$, $\gamma_2 = 0$, $\gamma_{f1}=0$, and $\gamma_{f2} = 0.8$. Correlations: corr(remit_epsf,y_epsf) = -0.7381, corr(remit_epsf,b_epsf) = 0.9406.

Figure 3: IRFs for Shock to Foreign Productivity – Dependent Economies



Note: Generated by Dynare for a one standard deviation shock to ε_t. Parameters: $\gamma_1 = 0.8$, $\gamma_2 = 0.10$, $\gamma_{f1}=0$, and $\gamma_{f2} = 0.8$. Correlations: corr(remit_epsf,y_epsf) = 0.0627, corr(remit_epsf,b_epsf) = -0.4374.

Figure 4(a): Parameter 3-D Surfaces for γ_{f2} = 0.4, 0.5, 0.65, and 0.95

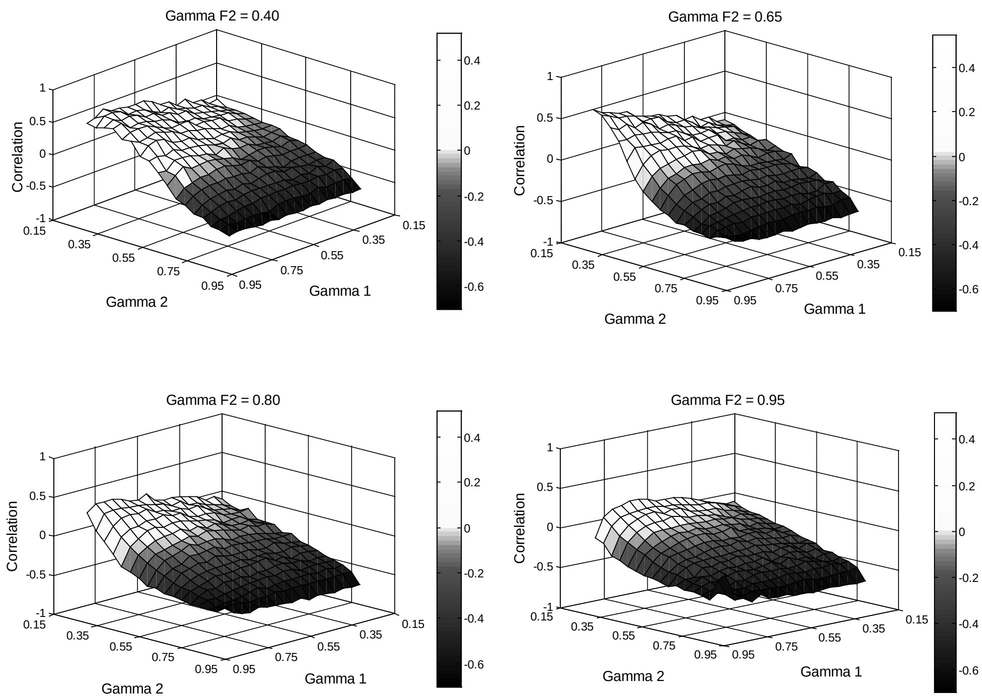


Figure 4(a): Parameter 2-D View of Surfaces for γ_{f2} = 0.4, 0.5, 0.65, and 0.95

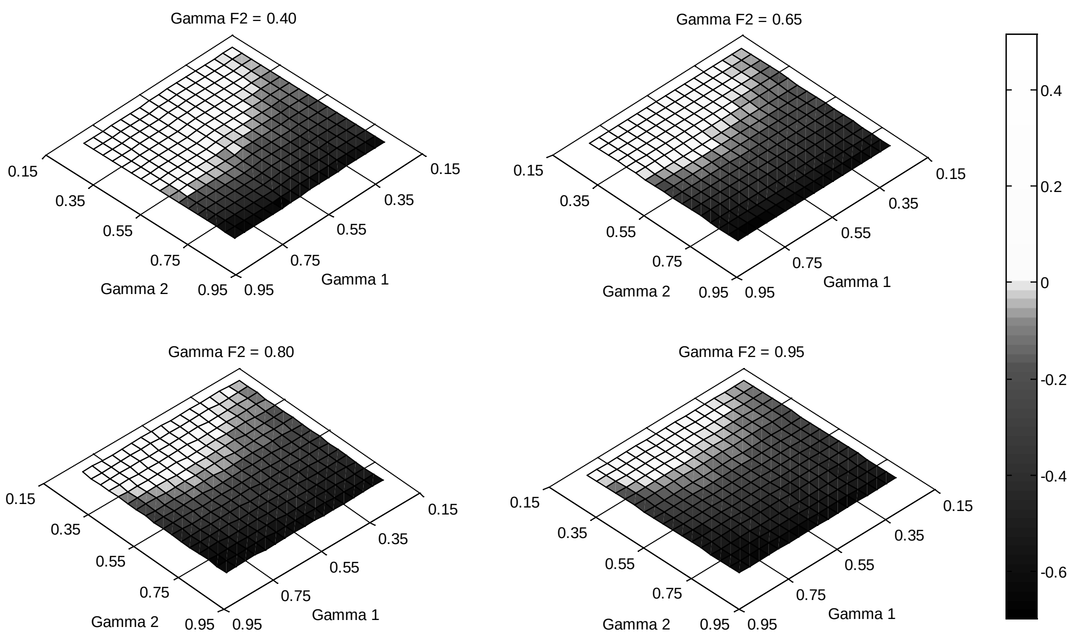


Figure 5: Correlations between domestic GDP and Remittances – Histogram and Summary Statistics

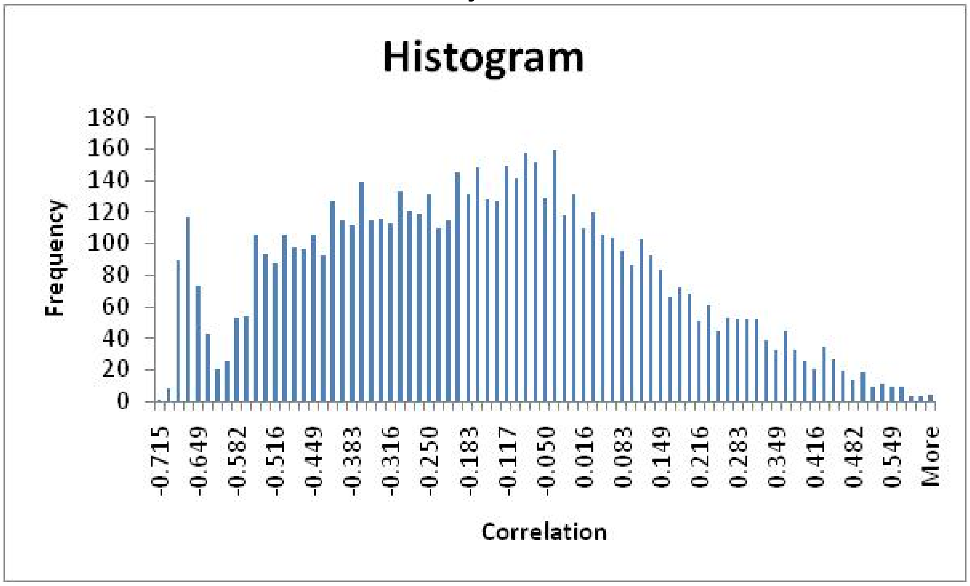


Figure 6: Min/Max Plot of Gamma 1 against Corr(GDP, Remit)

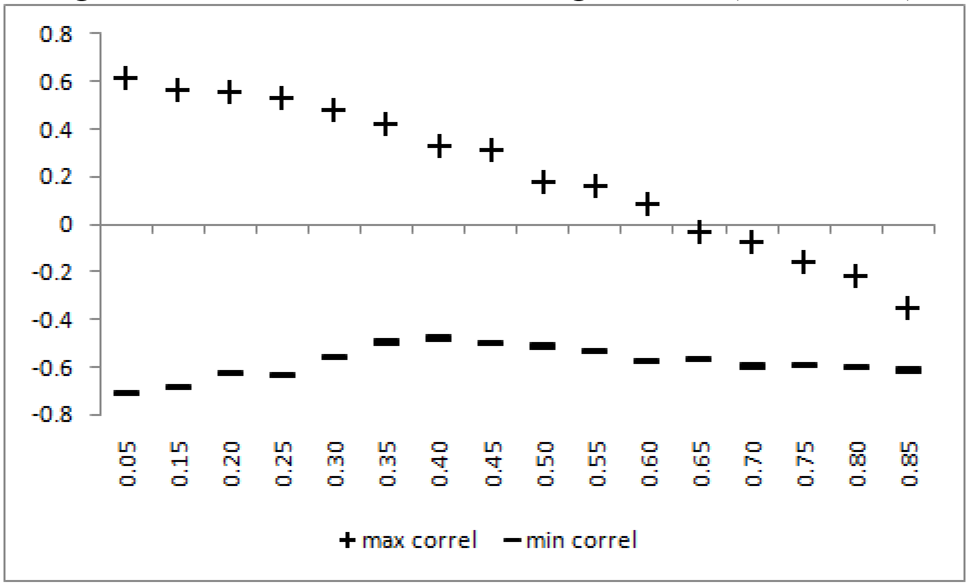


Figure 7: Min/Max Plot of Gamma 2 against Corr(GDP,Remit)

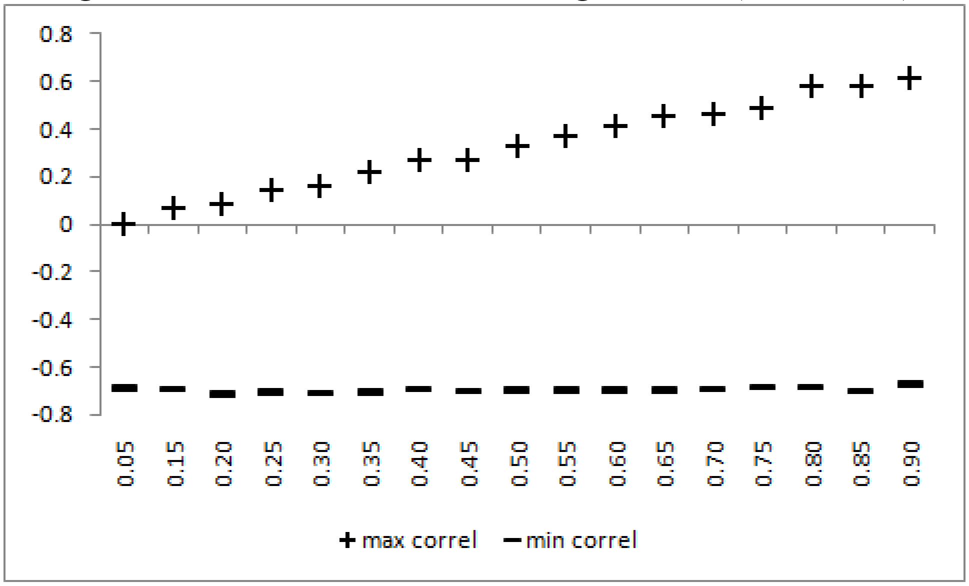


Figure 8: Min/Max Plot of Gammaf2 against Corr(GDP,Remit)

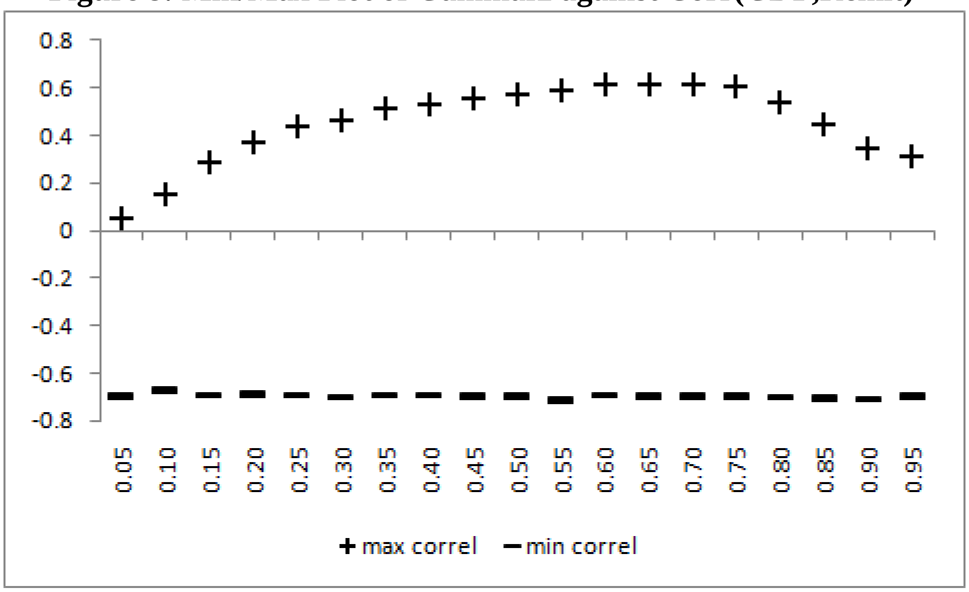


Table1: Simulation Description Statistics by Correlation

	Negative Correlations Only				Positive Correlations Only			
	obs	4651	71.8%		obs	1829	28.2%	
	gamma1	gamma2	gammaf2	corr	gamma1	gamma2	gammaf2	corr
	0.950	0.200	0.550	-0.715	0.050	0.900	0.650	0.615
	gamma1	gamma2	gammaf2	corr	gamma1	gamma2	gammaf2	corr
min	0.050	0.050	0.000	-0.715	0.050	0.150	0.050	0.000
max	0.950	0.950	0.950	0.000	0.600	0.950	0.950	0.615
mean	0.629	0.487	0.474	-0.304	0.251	0.611	0.478	0.187
std dev	0.223	0.275	0.306	0.192	0.135	0.209	0.236	0.141

Mathematical Appendix

Households are endowed with a stock of labor/leisure time that is constant and normalized to unity. At each point in time the household can allocate labor to the domestic labor market, h, the foreign labor market, h_f, or to neither labor market, L, otherwise known as leisure. The labor constraint is

(A.1.) $1 = L_t + h_t + h_{f,t}$.

Households have well defined utility over the consumption services of a single traded good, c, and labor services and have a constant subjective rate of time preference, β,

(A.2.) $E_t\left\{\sum_{t=0}^{\infty}\beta^t\left[\log(c_t) + Dh_t + D_{f,t}h_{f,t}\right]\right\}$.

where D and D_f are negative constants. This formulation follows Hansen's (1985) for indivisible labor. Assuming indivisible labor allows an analytically tractable modeling approach while also capturing relevant macroeconomic dynamics in the labor market. Hansen's (1985) logic is that each households are randomly selected with probability α each period, t, to sign a contract to provide a fixed amount, h_0, of labor. In each period, then, households provide labor, h_0, with $pr(work) = \alpha_t$ and don't supply labor with $pr(not\ work) = 1 - \alpha_t$. Since all households get paid the same wages whether they work or not, the institution functions like a social insurance contract.

Since $\alpha_t h_0$ hours of work are provided, labor demand is $h_t = \alpha_t h_0$ and rearranging this yields $pr(work) = \alpha_t = \frac{h_t}{h_0}$. An individual's logarithmic expected utility function can then be written as $u(c,h) = \ln(c) + pr(work)\ln(work) + pr(no\_work)\ln(no\_work)$. The total amount of time allocated is normalized to unity so that work allows $1\text{-}h_0$ leisure and no work gives the maximum amount of leisure which is 1. So, $u(c,h) = \ln(c) + \frac{h_t}{h0}\ln(1-h_0)$ since $ln(1) = 0$. Define $D = \frac{A\ln(1-h_0)}{h_0}$ and thus, $u(c,h) = \ln(c) + Dh_t$. Note that $1\text{-}h_0$ is a fraction, so its log is negative, hence D < 0.

With 2 labor markets the logic is that households contract to supply fixed labor, h_0 or h_{f0}, to the home or foreign market with $pr(work\ domestic) = \alpha_t$ and $pr(work\ \ foreign) = \alpha_{ft}$. Thus, $pr(no\ work) = 1 - \alpha_t - \alpha_{ft}$. This assumes a single household can work in only one market at a time and are randomly chosen and randomly assigned to the market in which they must work. Now,

$u(c,h,h_f) = \ln(c) + pr(work\ domestic)u(work\ domestic) + pr(work\ \ foreign)u(work\ \ foreign)$

Since "no work" yields zero utility, as above, it has already been dropped to save space. And, $u(c,h,h_f) = \ln(c) + \frac{h_t}{h_0}\ln(1-h_0) + \frac{h_{f,t}}{h_{f0}}\ln(1-h_{f0})$. This reflects, again, that individual households work in either the domestic or the foreign sector, but not both. Thus, if working domestically, then $h_f = 0$ and $L = 1\text{-}h_0$, which work in the foreign sector implies $h = 0$ and $L = 1\text{-}h_{f0}$. Define $D = \frac{\ln(1-h_0)}{h_0}$ and $D_f = \frac{\ln(1-h_{f0})}{h_{f0}}$. The utility function is thus $u(c,h,hf) = \ln(c) + Dh_t + D_f h_{ft}$ which is used in the functional (1.2).

Households maximize (1.2) subject to the following real flow budget constraint

(A.3.) $b_t + k_t + c_t = Rw_{f,t}h_{f,t} + w_t h_t + r_t k_{t-1} + (1-\delta)k_{t-1} - \frac{\kappa}{2}(k_t - k_{t-1})^2 + (1 + r_{b,t-1})b_{t-1}$

The model doesn't include the fraction $1\text{-}R$ that isn't remitted home. This amount is thought of as the financial cost of migrating and living abroad.

We assume an upward sloping supply curve for international funds,

(A.4.) $r_{b,t} = r^w - xB_t$.

A representative household implies aggregate and individual borrowing are equal, $b_t = B_t$.

There are two identical industrial sectors, both perfectly competitive in their input and output markets. The first is domestic

(A.5.) $\pi_t = A_t k_{t-1}^{\theta} h_t^{1-\theta} - w_t h_t - r_t k_{t-1} = 0$,

while the other sector is in the foreign country,

(A.6.) $\pi_{f\,t} = A_{f,t} k_f^{\theta} h_{f,t}^{1-\theta} - w_{f,t} h_{f,t} - r_{f,t} k_{f,t-1} = 0$.

The foreign economy is not modeled explicitly, so k_f is assumed constant but not removed for completeness and calibration purposes.

The processes A and A_f are stochastic and defined as

(A.7.) $\begin{pmatrix} A_t \\ A_{f,t} \end{pmatrix} = \begin{pmatrix} \rho & 0 \\ 0 & \tau \end{pmatrix} \begin{pmatrix} A_{t-1} \\ A_{f,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \varepsilon_{f,t} \end{pmatrix}$

where $E_t\{\varepsilon_t\} = E_t\{\varepsilon_{f,t}\} = 0$, $E_t\{\varepsilon_t \varepsilon_s\} = \sigma_\varepsilon^2 \;\forall t = s$ and 0 otherwise, $E_t\{\varepsilon_{f,t}\varepsilon_{f,s}\} = \sigma_f^2 \;\forall t = s$ and 0 otherwise, and finally, $E_t\{\varepsilon_t \varepsilon_{f,t}\} = \varphi\sigma_\varepsilon\sigma_f \;\forall t = s$ and 0 otherwise.

Lagrangian:

(A.8.) $L = E_t \sum_{t=0}^{\infty} \beta^t \begin{Bmatrix} \ln(c_t) + (Dh_t + D_f h_{f,t}) + \mu_t [Rw_{f,t}h_{f,t} + w_t h_t + r_t k_{t-1} + (1-\delta)k_{t-1} + (1 + r_{b,t-1})b_{t-1} \\ -b_t - k_t - c_t - \frac{\kappa}{2}(k_t - k_{t-1})^2] \end{Bmatrix}$

First Order Conditions:

(A.9.) $L_C : \frac{1}{c} = \mu_t$

(A.10.) $L_h : D = -\mu_t w_t$

(A.11.) $L_{hf} : D_f = -\mu_t R w_{f,t}$

(A.12.) $L_k : -\mu_t(1 + \kappa(k_t - k_{t-1})) + \beta E_t \mu_{t+1}[r_{t+1} + (1-\delta) + \kappa(k_{t+1} - k_t)] = 0$

(A.13.) $L_b : -\mu_t + \beta E_t \mu_{t+1}(1 + r_{b,t}) = 0$

(A.14.) $L_\mu : Rw_{f,t}h_{f,t} + w_t h_t + r_t k_{t-1} + (1-\delta)k_{t-1} + (1+r_{b,t-1})b_{t-1} - b_t - k_t - c_t - \frac{\kappa}{2}(k_t - k_{t-1})^2 = 0$

Relevant Equations:

(A.15.) $D = -\frac{w_t}{c_t}$

(A.16.) $D_f = -\frac{Rw_{f,t}}{c_t}$

(A.17.) $1 = \beta E_t \frac{c_t}{c_{t+1}}(1 + r_{b,t})$

(A.18.) $(1+\kappa(k_t - k_{t-1})) = \beta E_t \frac{c_t}{c_{t+1}}[r_{t+1} + (1-\delta) + \kappa(k_{t+1} - k_t)]$

(A.19.) $b_t + k_t + c_t = Rw_{f,t}h_{f,t} + w_t h_t + r_t k_{t-1} + (1-\delta)k_{t-1} + (1+r_{b,t-1})b_{t-1} - \frac{\kappa}{2}(k_t - k_{t-1})^2$

From the firms' optimization problem:

(A.20.) $r_t = \theta A_t k_{t-1}^{\theta-1} h_t^{1-\theta}$

(A.21.) $w_t = (1-\theta) A_t k_{t-1}^{\theta} h_t^{-\theta}$

(A.22.) $w_{f,t} = (1-\theta) A_{f,t} \bar{k}_f^{\theta} h_{f,t}^{-\theta}$

(A.23.) $r_{b,t} = r^w - xB_t$

(A.24.) $A_t = \gamma_1 A_{t-1} + \gamma_2 A_{f,t-1} + \varepsilon_t$ where $E_t(\varepsilon_{t+1}) = 1 - \gamma_1 - \gamma_2$

(A.25.) $A_{f,t} = \gamma_f A_{f,t-1} + \varepsilon_{f,t}$ where $E_t(\varepsilon_{f,t+1}) = 1 - \gamma_f$

(A.26.) $b_t = B_t$

Equating (A.15) and (A.16) and combing with (A.21) and (A.22) yield equation (2.3) in the paper: $A_t k_{t-1}^{\theta} h_t^{-\theta} = \left(\frac{D}{D_f}\right) R A_{f,t} k_f^{\theta} h_{f,t}^{-\theta}$.

Since we are interested in correlations between remittances and domestic output, we include

(A.27.) $y_t = r_t k_{t-1} + w_t h_t$ or $y_t = A_t k_{t-1}^{\theta} h_t^{1-\theta}$

(A.28.) $remit = Rw_{f,t}h_{f,t}$

In steady state:

(A.29.) $\bar{A} = 1$

(A.30.) $\bar{A}_f = 1$

(A.31.) $\bar{r} = 1/\beta - (1-\delta)$

(A.32.) $\bar{b} = \dfrac{(r^{w} + 1 - 1/\beta)}{a}$

(A.33.) $\bar{w} = (1-\theta)\left(\dfrac{\theta}{\bar{r}}\right)^{\frac{\theta}{1-\theta}}$

(A.34.) $\overline{w_f} = \dfrac{D_f \bar{w}}{DR}$

(A.35.) $\bar{c} = -\dfrac{\bar{w}}{D}$

(A.36.) $\overline{r_b} = r^{w} - a\bar{b}$

(A.37.) $\overline{h_f} = \left(\dfrac{(1-\theta)\overline{A}_f}{\overline{w}_f}\right)^{\theta} \bar{k}_f$ or, as we do in Dynare, $\overline{h_f} = \left(\dfrac{(1-\theta)\overline{A}_f D_f \bar{w}}{RD}\right)^{\theta} \bar{k}_f$

(A.38.) $\bar{k} = \dfrac{\left(\bar{c} - \bar{r}_f \bar{b} - R\overline{w_f}\,\overline{h_f}\right)}{\left(\dfrac{r}{\theta} - \delta\right)}$

(A.39.) $\bar{h} = \dfrac{(1-\theta)}{\theta}\dfrac{\bar{r}}{\bar{w}}\bar{k}$

(A.40.) $\bar{\varepsilon} = 1 - \gamma_1 - \gamma_2$

(A.41.) $\overline{\varepsilon_f} = 1 - \gamma_f$

(A.42.) $\bar{y} = \bar{r}\bar{k} + \bar{w}\bar{h}$

(A.43.) $\overline{remit} = R\bar{w}_f \bar{h}_f$

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