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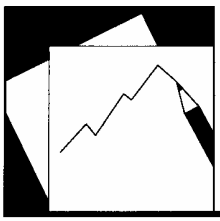

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Beware of Emigrants Bearing Gifts: Optimal Fiscal and Monetary Policy in the Presence of Remittances

Ralph Chami, Thomas F. Cosimano, Michael T. Gapen

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Beware of Emigrants Bearing Gifts: Optimal Fiscal and Monetary Policy in the Presence of Remittances

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Abstract

This paper uses a stochastic dynamic general equilibrium model to investigate the influence of countercyclical remittances on the conduct of fiscal and monetary policy and trace their effects on real and nominal variables in a business cycle setting. We show that remittances raise disposable income and consumption, and insure against income shocks, thereby raising household welfare. However, remittances increase the correlation between labor and output, thereby producing a more volatile business cycle and increasing output and labor market risk. Optimal monetary policy in the presence of remittances deviates from the Friedman rule, highlighting the need for independent government policy instruments.

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I. INTRODUCTION

The World Bank's recent *Global Economic Prospects* (World Bank, 2006) estimates official remittances received by developing countries in 2005 were $167 billion, up 73 percent from 2001. When estimates of unrecorded remittances – or remittances flowing through unofficial channels – are added, the magnitude rises by about 50 percent, bringing the total estimate of these flows to around $250 billion. According to World Bank (2006), the magnitude of remittances in many developing countries has surpassed official development assistance (ODA), private equity flows, and foreign direct investment (FDI), and their rate of growth has outpaced that of official and private capital flows. Given the implication of such transfers for recipient countries, there is now an avid interest among researchers and policymakers in analyzing the economic and social impact of remittances on the economies of the receiving countries.

The existing literature on remittances has mainly focused on the motivation for these transfers and their microeconomic implications.[2] On the motivation to remit, the literature has examined whether remittances are altruistically motivated or behave more like investment-related capital flows. Altruism would suggest remittances are countercyclical relative to income in the recipient economy while remittances as capital flows would suggest a procyclical relationship. Chami, Fullenkamp, and Jahjah (2003, 2005) show that the characteristics of remittances as person-to-person private income flows differ from other private capital flows.[3] Using a microfoundations approach and panel techniques, they show that remittances, unlike other capital flows, are countercyclical and may have unintended consequences for economic growth. Subsequent econometric studies such as World Bank (2006), IMF (2005b), and Mishra (2005) have confirmed the countercyclicality result and suggest, therefore, that remittance behavior appears to be altruistically motivated. However, the existing literature has been largely silent on the impact of remittances as countercyclical income transfers on government policy and the macro economy, especially in the context of a fully specified general equilibrium framework. This paper is an attempt to fill this void.

The main purpose of this paper is to shed light on how the behavior of real and nominal variables differ in remittance-dependent economies, where the ratio of remittances to gross domestic product (GDP) is significant, from the same variables in economies that do not

[2] See Taylor (1999) for an extensive review of the literature on remittances.

[3] Despite having the same title, the Chami, Fullenkamp, and Jahjah (2003, 2005) differ in exposition and treatment of remittances. Chami, Fullenkamp, and Jahjah (2003) includes discussion on the impact of remittances on growth while Chami, Fullenkamp, and Jahjah (2005) focuses on the countercyclical properties of remittances. Both papers use different model frameworks to generate their results. Due to these differences, we choose to cite both studies simultaneously throughout this paper.

receive remittances, or where the size of these flows relative to GDP is small. To accomplish this, we develop a stochastic dynamic general equilibrium model with money and distortionary government policy to investigate the implication of remittances for the conduct of monetary and fiscal policy in a country that receives such private income flows. To remain consistent with the findings from the recent econometric studies mentioned above, remittances are exogenously specified as countercyclical real income transfers to households. We believe that this is the first such exercise in a fully specified general equilibrium setting.

We are able to show that economic decision making and optimal monetary and fiscal policy will differ in important ways in remittance-dependent economies from non-recipient countries. When the household receives remittances in addition to income from production, the household seeks to spread these additional resources across consumption and leisure according to their respective marginal utility. The reduction in steady-state labor supply leads to reduced domestic output, but the drop in income from production is not enough to offset the additional resources from remittances. Therefore, total household resources increase in the presence of remittances, despite the desire by the household to increase leisure. Increases in net household resources lead to an increase in household consumption, confirming the widespread belief that remittances can play an important role in poverty reduction and improved standards of living.

The presence of remittances, however, alters optimal monetary and fiscal policy. In the baseline economy without remittances, optimal government policy follows the Friedman rule, which is consistent with the finding by Alvarez, Kehoe, and Neumeyer (2004) and Chari, Christiano, and Kehoe (1991, 1996) that the Friedman rule is optimal in a variety of monetary economies with distortionary taxes. In contrast, the economies with remittances produce higher steady-state rates of labor taxation, higher debt levels, and money growth as the government seeks to finance the same level of spending while raising revenue from a smaller base of domestic production. Optimal monetary policy in the presence of remittances, therefore, deviates from the Friedman rule as the government finds it optimal to use the inflation tax. Following the recent survey by Kocherlakota (2005), non-optimality of the Friedman rule in a representative agent model with flexible prices is unusual. Yet the household is better able to absorb the increase in distortionary government policy on the margin since government policy acts on a smaller portion of total household resources. The presence of remittances lowers the marginal cost of distortionary government policy, or the marginal cost to the household from an additional dollar of revenue raised by the government. Remittances, in other words, also serve to insulate the household from distortionary government policy.

Despite the fact that remittances are exogenously specified as countercyclical, their presence increases the correlation between labor and output, creating a procyclical effect on

the business cycle. In remittance-dependent economies, household decisions are based on the interaction between income from the domestic production process and income transfers from the remittance function. If the economy receives a negative productivity shock, for example, the drop in output via the production function would induce the household to increase its labor supply according to standard consumption smoothing arguments. However, in the presence of remittances, the drop in domestic output results in higher remittance transfers since they are countercyclical. Higher remittances mean the household has more resources, which has the effect of reducing the supply of labor. As remittances increase in size and importance, the labor effect of remittances increases relative to the effect from production, serving to increase the correlation between labor and output. The finding of increased procyclicality means that remittances have the undesirable effect of raising business cycle volatility. The increase in business cycle volatility also translates into higher risk in the labor market through higher wage and labor supply volatility. Thus, while Chami, Fullenkamp, and Jahjah (2003, 2005) use asymmetric information assumptions to argue that remittances increase labor market risk, we find this to be the case in a model with flexible prices and full information.

Offsetting the increase in business cycle volatility is the finding that countercyclical remittances provide consumption insurance against income shocks. As the remittances-to-income ratio rises, model simulations indicate that volatility of household consumption generally remains constant in the face of successively increasing output risk. This result is due to the cash-credit model specification, meaning the household can contemporaneously transfer remittances into credit good consumption during the period in which remittances are received. We also show that remittances lead to a net increase in household welfare, as their labor-leisure trade-off and consumption smoothing effect enhance the per-period utility of the recipients of such transfers sufficiently to outweigh any negative impact of increased domestic income risk.

By changing the correlation between labor and output, remittances also serve to increase the countercyclicality of government policy. Following the arguments found in Tinbergen (1956), the changing correlations of underlying economic variables in the presence of remittances mean the government in this case does not have a sufficient number of independent policy instruments to meet all of its objectives simultaneously. Consequently, the government finds it optimal to violate the Friedman rule and use its remaining policy instrument, the inflation tax on nominal money balances, since the debt stock alone is not rich enough to adequately control the incentives of successive governments. The inflation tax acts as a tax on remittances since households are forced to accumulate cash prior to purchase units of the cash good, exposing the household to the risk of unexpected inflation. One important conclusion that can be drawn from non-optimality of the Friedman rule in the presence of remittances, therefore, is that the government needs to have a sufficiently rich set of policy instruments to carry out its policy plans.

The paper generates these results by combining the traditional general equilibrium framework of macroeconomics with the public finance approach from Ramsey (1927) to calibrate and simulate a stochastic monetary model under various remittance-to-income ratios. The model is a combination of a cash-in-advance model and a stochastic growth model with a fixed capital stock, similar to models employed in Cooley and Hansen (1995), Chari, Christiano, and Kehoe (1991), and Lucas and Stokey (1983). The household derives utility from leisure and consumption while the government raises revenue to finance its exogenous stochastic spending through labor taxes and the ability to print money, both of which have distortionary effects. The government also has the ability to issue one-period, fixed-rate real debt.

When choosing a combination of fiscal and monetary policy, the government must take into account the relationship between this policy mix, remittances, and household labor supply to minimize distortions. Optimal policies, or Ramsey policies, maximize consumer welfare while minimizing distortions within the system. The presence of nonlinear distortions to labor requires the use of a simulation procedure which captures these effects. The computational solution procedure is based on the projection approach as described by Judd (1992, 1998) and applied to Ramsey problems in Cosimano and Gapen (2005). In particular, the projection method defines the policy functions in terms of Chebyshev polynomials and then solves the Euler conditions for the optimal Ramsey policy for money growth, taxes, labor supply, and the multiplier on the government budget constraint.

The model examines the relationship between remittances and government policy by preserving the endogeneity of the marginal product of labor and the nonlinearity of the labor supply function. Remittances, the contemporaneous tax on labor income, and money growth are all determinants of optimal household labor supply in equilibrium. Shocks that cause variations in both government policy and remittances are transmitted through optimal labor supply to output, remaining household allocations, and the equilibrium price system while feeding back into the government budget constraint through tax revenue. Equilibrium decisions are then passed into future periods through the price level and interest rate equations. Preserving the endogeneity of the marginal product of labor has the advantage of maintaining an important channel for the evaluation of optimal household decisions in the presence of distortions. The approach in this paper represents a significant departure from recent studies on optimal government policy (e.g., Aiyagari and others, 2002; Alvarez, Kehoe, and Neumeyer, 2004; and Schmitt-Grohé and Uribe, 2004) that assume linear labor supply and exogenous marginal product of labor, which eliminates this important channel in household decision making.

The paper proceeds as follows. Section II describes some stylized facts about remittances and examines the various motivations behind remittance activity. This is followed in Section III by a discussion of the model framework. Section IV describes the Ramsey

problem and implementation of the nonlinear solution procedure. Finally, Section V illustrates the main results under various levels of remittances followed by concluding remarks in Section VI.

II. Remittances and Their Motivation

Remittances are defined as private income transfers that take place between family members. In many cases, one or more family members live and work abroad while regularly transferring, or remitting, income back to the remaining family unit in the home country. The typical transfer amount does not exceed a few hundred dollars, but millions of these transfers take place worldwide through both formal and informal channels. The decision by the remitter to use official or unofficial channels, such as the family and friends network, for remittance purposes depends on a number of factors. These include the number and type of restrictions placed by recipient countries on foreign exchange flows, the level of transaction costs imposed by financial intermediaries, as well as other types of capital controls (see World Bank, 2006, Chapter 6). The cost to remit is a significant determinant of the choice to remit through formal or informal channels as costs can vary substantially. Analysis by Köksal (2006) and Köksal and Liebig (2005) suggests that fees generally range from 1 to 2 percent of the amount remitted in larger transactions , and up to as much as 20 percent on smaller transactions. Despite these costs, remittance flows to developing countries have grown substantially, increasing from $31 billion in 1990 to $167 billion in 2005.[4] Remittances typically flow from developed to developing economies, though estimates of south-south remittances are also considerable.

As shown in Figure 1, developing countries now receive remittances in significant amounts, with the top 20 remittance-dependent countries recording annual flows of between 7 and 27 percent of GDP during 2003. Annual averages over the period 1990-2003 paint a similar picture, as the top 20 developing countries received remittance flows between 4 and 18 percent of GDP. The recipients of the largest remittance flows are India, Mexico, and the Philippines, each of whom received between $7 and $14 billion in remittances during 2002. These three countries have been consistent recipients of remittances, recording the largest average annual flows between 1990 and 2002.[5] As reported by IMF (2005b) and World Bank (2006), the largest source of remittances is the United States and the two largest

[4] World Bank (2006). Remittances are defined in the broadest possible terms to include workers' remittances, compensation of employees, and migrant transfers. Total worldwide remittances, which include remittances to both developed and developing economies, were estimated at $232 billion in 2005. Remittances to developing countries, therefore, constitute over 70 percent of total remittance flows.

[5] Many developed countries such as Spain and France also receive significant remittance inflows, but these amounts are negligible in terms of GDP.

destination regions of remittance flows are Latin America and developing Asia. These studies both indicate that remittance flows are beginning to outpace official transfers, private equity flows, and FDI. Across the Caribbean, for example, Mishra (2005) reports that remittances increased from 3 to 13 percent of GDP from 1990 to 2002, while FDI fell from 11 to 7 percent and ODA fell from 4 to 1 percent. Across all developing countries, IMF (2005b) reports that remittances are now the second largest inflow behind FDI, but ahead of ODA and non-FDI private capital inflows.[6] The need to understand the impact of these flows on economic decision making is readily apparent.

The existing literature on remittances has mainly focused on the motivation to remit and the microeconomic implications of remittances. On the motivation for remittances, the literature has been divided between those who argue that remittances are altruistically motivated and those who believe that remittances behave more like capital flows – that is, they are driven by selfish reasons and the remitter's desire to invest in the home country. This latter approach has often been referred to as the portfolio motive behind remittances and has been advanced in a variety of studies, including Straubhaar (1986), Elbadawi and Rocha (1992), El-Sakka and McNabb (1999), and Buch, Kuckulenz, and Le Manchec (2002) to suggest that remittances promote development and enhance growth opportunities. The theory of altruistically motivated remittance flows is related to family ties in the home country and the desire of the remitter to provide resources and care for those family members left behind. Altruistic motivations for remittances are discussed in Lucas and Stark (1985), Chami, Fullenkamp, and Jahjah (2003, 2005), Gupta (2005), and World Bank (2006), and have their roots in Becker's (1974) analysis on economics of the family. Lucas and Stark (1985) specify a utility function in which the remitter's utility includes consumption of the remaining household members in the home country. Altruistically motivated remittance behavior is, therefore, consistent with existing theory on altruistically motivated bequest behavior, where utility of the parents includes lifetime resources of their children.

Establishing the primary motivation behind remittance behavior is important since the altruistic and portfolio motives have different implications for the relationships between remittances, household decisions, and other economic variables of interest in the receiving country. For example, if remittance flows are primarily portfolio motivated, then one would expect remittances, like investment, to be procyclical relative to output in the receiving country. However, if remittances were primarily motivated by altruistic behavior on the part of the remitter, then remittances as compensatory income transfers would be countercyclical relative to output in the receiving country. The remitter would attempt to

[6] The dramatic growth in remittances may also simply reflect the concerted effort to bring these transactions into the formal transfer market as governments have intensified efforts to control money laundering and other potentially illicit transactions.

remit more when economic conditions were worsening in the home country and may remit less during economic expansions in the home country.

An examination of the existing econometric studies on remittance behavior suggests that remittances are primarily motivated by altruism. Chami, Fullenkamp, and Jahjah (2003, 2005) develop a model for examining the causes of remittances and, using cross-country data from 1970-98, find that remittances tend to be negatively correlated with GDP growth while capital flows such as FDI have a positive correlation. The authors conclude that remittances appear to be primarily intended to serve as compensation for poor economic performance in the home country. More recently, IMF (2005b) uses annual data on a panel of 87 countries from 1980 to 2003, Mishra (2005) investigates data for 13 Caribbean countries from 1980 to 2002, and World Bank (2006) examines cross-country data from 1995 to 2003. Like Chami, Fullenkamp, and Jahjah (2003, 2005), these studies find that remittances are countercyclical.[7] Though these studies cite other factors as important determinants of remittances in addition to home country income, we focus only on the income of remittance recipients in the home country since it is instructive in the model specification that follows.[8] Inclusion of the remaining factors does not change the thrust of the present exercise. Therefore, although some support for the portfolio motive behind remittance behavior exists (e.g., Lucas and Stark, 1985; and Mishra, 2005), altruism appears to dominate in a cross-country setting.

The literature, however, has largely been silent on the impact of countercyclical remittance flows on government policy and the macro economy, especially in the context of a fully specified general equilibrium framework. Studies examining the macroeconomic implications of remittances have instead relied on surveys of households in different countries. Recently, Adams (2004) uses household surveys to look at the role of remittances in alleviating poverty in Guatemala while Amuedo-Dorantes, Bansak, and Pozo (2005) examine remittance patterns from Mexico survey data. Finally, McKenzie (2005) investigates the impact of these flows on Mexican household decisions and allocation of resources.[9] In contrast to the micro-based literature, the existing macroeconomic studies do not utilize an optimizing framework when examining the impact of remittances, which hinders a systematic analysis of these flows. Thus, one of the main contributions of this paper is to provide such a optimizing framework. We proceed in the next section by

[7] Additional single-country analysis by Gupta (2005) and Bouhga-Hagbe (2004) also lends empirical support for the altruistic motive.

[8] Chami, Fullenkamp, and Jahjah. (2003, 2005), World Bank (2006), IMF (2005), and Bougha-Hagbe (2004), among others, indicate that other important determinants of remittances include the income of the remitter in the host country (proxied by the host country output), the degree of attachment to the family and home country, and other demographic factors, including the number of years in host country.

[9] See also Lucas and Stark (1985) for remittances in Bostwana and Agarwal and Horowitz (2002) for remittances in Guyana.

developing a stochastic dynamic general equilibrium model with distortionary government policy in order to investigate the implication of countercyclical remittance flows on economic decision making and the conduct of monetary and fiscal policy in a business cycle setting.

III. A Stochastic Monetary Economy with Remittances

The properties of remittances and their relation to optimal policies and allocations are examined in a stochastic monetary economy. The model is a combination of a cash-in-advance model and a stochastic growth model, similar to models employed in Cooley and Hansen (1995), Chari, Christiano, and Kehoe (1991), and Lucas and Stokey (1983). The economy has a representative household, a representative firm, a government, and remitters. The household derives utility from leisure and two consumption goods, a cash good and a credit good where previously accumulated cash balances are needed to purchase units of the cash good. Output is produced according to a production function that combines capital, labor, and technology, where the process governing technology is assumed to be exogenous and stochastic. Given the preponderance of evidence on the altruistic motive for remitting, the household in this economy receives remittances which are exogenously specified as countercyclical real income transfers. These transfers augment the income received from production.

The government raises revenue with distortionary effects to finance its exogenous stochastic spending using a tax on labor income, printing money, or debt issuance through one-period real bonds. The government, however, is unable to levy a direct tax on remittance income flows, an assumption which accords with evidence from various studies (e.g., World Bank 2006, p. 93) which report that remittances are not typically taxed directly by governments. Finally, as in Lucas and Stokey (1983), Alvarez, Kehoe, and Neumeyer (2004) and others, this framework does not include a tax on capital and therefore avoids the well understood problems arising from capital taxation in representative agent models.[10]

Assumptions of a fixed capital stock and logarithmic preferences enable computation of closed form equilibrium solutions for the private sector given a particular government policy. The Ramsey equilibrium solves for optimal fiscal and monetary policy in the

[10]In addition to ruling out taxation of the pre-existing stock of capital, an assumed zero capital tax is also justified by the well established result that tax rates on capital should be close to zero on average in the context of representative agent models. For other work on optimal capital taxation in this setting, see Atkinson (1971), Diamond (1973), Pestieau (1974), Atkinson and Sandmo (1980), Judd (1985), Chamley (1986), and Chari, Christiano, and Kehoe (1991, 1994). In the context of heterogeneous agents, however, a positive tax rate on capital has been found to be optimal. Auerbach and Kotlikoff (1987), for example, detail capital taxation in an overlapping generations setting, while Aiyagari (1995) shows how idiosyncratic risk and borrowing constraints lead to positive capital taxes.

presence of remittances given the equilibrium behavior of the private sector. This Ramsey equilibrium may be reduced to four operator equations given the equilibrium behavior of interest and prices. The system is nonlinear, and therefore the projection method is applied to solve for the four policy functions and conduct simulations. If the private sector is made more complex, these four conditions would need to be augmented with equilibrium conditions for interest rates and prices. These additional conditions would limit the accuracy of the projection method since additional equations would limit the number of nodes the computer can solve. Finally, given a fixed capital stock, the model highlights the distortionary effects of policy. The optimal government policy will account for its impact on interest rates, prices, and remittances as well as on the optimal behavior of the household and firms.

A. Production

Aggregate output, Y_t, is produced according to the following constant returns-to-scale production function,

$$Y_t = \exp(\theta_t) H_t^{\alpha} K_t^{1-\alpha}, \quad 0 < \alpha < 1, \tag{1}$$

where K_t and H_t are the aggregate capital stock and labor supply, respectively, and θ_t represents the available technology. Technology is assumed to be the realization of an exogenous stochastic process and evolves according to the following law of motion,

$$\theta_t = \rho_\theta \theta_{t-1} + \epsilon_{\theta,t}, \quad 0 < \rho_\theta < 1. \tag{2}$$

The random variable, $\epsilon_{\theta,t}$, is normally distributed with mean zero and standard deviation $\sigma_{\theta,t}$ and the realization of $\epsilon_{\theta,t}$ is known to all agents at the beginning of period t. The restriction in this paper on labor's share of income below unity means labor supply is nonlinear and marginal product of labor is endogenous.[11] As discussed in the proceeding section, the solution procedure used in this analysis preserves the nonlinearity of the labor supply function and associated Jensen's inequality effects, thereby capturing the cost of government policy and its interaction with remittances through the endogeneity of the marginal product of labor.

Investment in physical capital in period t produces capital in period $t+1$ according to,

$$K_{t+1} = (1-\delta) K_t + X_t, \quad 0 < \delta < 1, \tag{3}$$

[11] The production function in equation (1) has meaningful implications which differ from similar recent work by Aiyagari and others (2002), Alvarez, Kehoe, and Neumeyer (2004), and Schmitt-Grohé and Uribe (2004). These authors set $\alpha = 1$ in which results in an exogenous marginal product of labor equal to $\partial Y/\partial H = \exp(\theta)$. Setting $0 < \alpha < 1$ results in an endogenous marginal product of labor of $\partial Y/\partial H = f(\alpha, \exp(\theta), H, K)$.

where X_t is the level of investment in period t and δ is the rate of depreciation. The capital stock is assumed to be fixed so that $X_t = X = \delta K$ and firms are assumed to take depreciation charges before taxes are applied at the household level. If firms were not allowed to take depreciation charges before taxes were applied, the government would find it optimal to tax inelastically supplied investment and use the proceeds to retire money balances. The representative firm seeks to maximize profit by choosing labor supply resulting in the standard first-order conditions for the wage rate and rental rate on capital, adjusted for constant capital.

B. Households, Remittances, and the Government

The representative household obtains utility from consumption and leisure. Preferences are summarized by the following utility function,

$$E_t \sum_{t=0}^{\infty} \beta^t \left[a \log C_{1t} + (1-a) \log C_{2t} - \gamma H_t \right], \tag{4}$$

where C_1 is the cash good, C_2 is the credit good, γ is a positive constant and $0 < \beta, a < 1$. The specification of linear disutility of labor is derived from the assumptions that labor is indivisible and allocation of labor is determined by employment lotteries (Hansen, 1985; and Rogerson, 1988). The household enters period t with previously accumulated assets equal to the stock of money holdings, M_t, and gross returns from government bonds, $B_t R_{t-1}$, where B_t is the stock of bonds and R_{t-1} is the gross real interest rate.

Following the results of the empirical studies that show remittances to be countercyclical, the household receives remittances in the form of a compensatory income transfer equal to,

$$Rem_t = r_0 \left(\frac{\overline{Y}}{Y_t} \right)^{r_1}, \tag{5}$$

where $\overline{Y}$ is the steady-state level of output and r_0 and r_1 are positive constants. The responsiveness of remittances to the business cycle is determined by the parameter r_1 and the steady-state level of remittances is equal to r_0. Since remittances are additional household income outside the production process and the capital stock is assumed to be fixed, the remittance function above models remittances as a pure income transfer.

Previously accumulated assets, income from production, and remittance income are all used to finance household expenditures during the period. Entering the period, the current shocks to the economy are revealed. As a result, households know the past and current realization of technology and government spending and form expectations over future possible values. After the shocks are revealed and expectations are formed, the household

then decides labor supply, receives remittances, chooses consumption of the cash and credit goods, government bonds, and the amount of money to be carried into the next period. Overall, household allocations must satisfy the following budget constraint,

$$C_{1t} + C_{2t} + \frac{M_{t+1}^d}{P_t} + B_{t+1}^L \leq (1 - \alpha\tau_t)(Y_t - X) + Rem_t + \frac{M_t}{P_t} + B_t^L R_{t-1}^L, \tag{6}$$

where P_t is the price level and τ_t is the tax applied to labor income, αY_t. Remittances are not subject to taxation like labor income. The term M_{t+1}^d is the demand for money balances by the representative household to be used in the next period and is aggregated across households in relation to money supply in equilibrium. Previously accumulated money balances are used to purchase the cash good in the current period and must also satisfy the cash-in-advance constraint,

$$P_t C_{1t} \leq M_t. \tag{7}$$

Real government consumption, G_t, is assumed to follow an exogenous stochastic process. Government policy includes sequences of labor taxes and supplies of money and bonds which must satisfy the following budget constraint,

$$\frac{M_t}{P_t} + B_t R_{t-1} = \tau_t \alpha (Y_t - X) - G_t + B_{t+1} + \frac{M_{t+1}}{P_t}, \tag{8}$$

where the initial stocks of money, M_0, and bonds, B_0, are given. The money supply and government spending in period t are assumed to grow at the rate $\exp(g_t) - 1$ and $\exp(\mu_{t+1}) - 1$, respectively. Thus, the level of government spending and money stock are defined as,

$$G_t = \exp(g_t) G_{t-1}, \tag{9}$$

$$M_{t+1} = \exp(\mu_{t+1}) M_t. \tag{10}$$

The random variable g_t is assumed to evolve according to the following autoregressive process,

$$g_t = \rho_g g_{t-1} + \epsilon_{g,t}, \tag{11}$$

where $\epsilon_{g,t}$, is normally distributed with mean zero and standard deviation $\sigma_{g,t}$. Like the shock to technology, the realization of $\epsilon_{g,t}$ is known to all at the beginning of period t. The economywide resource constraint is,

$$C_{1t} + C_{2t} + X + G_t = Y_t + Rem_t, \tag{12}$$

which states that output from production plus remittances can be consumed by either

households or the government.

C. Solution to the Household Problem

The specification of log preferences causes income and substitution effects to cancel, allowing equilibrium remittances and household allocations to be characterized for a given set of government policy. The closed-form solutions for consumption and the price level are,

$$C_{1t} = \frac{(Y_t + Rem_t - X - G_t)\,\beta\left(\frac{a}{1-a}\right)\exp(-\mu_{t+1})}{1+\beta\left(\frac{a}{1-a}\right)\exp(-\mu_{t+1})}, \tag{13}$$

$$C_{2t} = \frac{(Y_t + Rem_t - X - G_t)}{1+\beta\left(\frac{a}{1-a}\right)\exp(-\mu_{t+1})}, \tag{14}$$

$$P_t = \frac{M_t}{(Y_t + Rem_t - X - G_t)}\left[\frac{1+\beta\left(\frac{a}{1-a}\right)\exp(-\mu_{t+1})}{\beta\left(\frac{a}{1-a}\right)\exp(-\mu_{t+1})}\right]. \tag{15}$$

The closed-form solution for the interest rate is found by inserting (14) at time t and $t+1$ into

$$R_t = \frac{1}{\beta C_{2t}}\left[\frac{1}{E_t\left[\frac{1}{C_{2t+1}}\right]}\right], \tag{16}$$

which is derived from the Euler condition on government bonds.

The solution for the credit good in (14) can also be used to solve for optimal labor supply, defining an implicit function,

$$H_t = h\left(g_t, \theta_t, \mu_{t+1}, \tau_t\right). \tag{17}$$

This equation cannot be solved for H_t explicitly, but the implicit function theorem allows for the construction of an implicit function which defines the explicit function. Defined derivatives can be obtained as long as an implicit function is known to exist under the implicit function theorem. Since an implicit function for equilibrium labor can be constructed,[12] optimal household allocations and the equilibrium price system are all functions of contemporaneous government policy, the exogenous shocks to government spending and technology, and the level of remittances. It is clear from equations (17), (1), and (5) that the realization of exogenous shocks and government policy determines labor supply, aggregate output, and aggregate remittances, respectively. Thus, while remittances are not directly subject to government taxation, government policy indirectly influences the

[12] See Cosimano and Gapen (2005) for additional details.

level of remittances through changes in the marginal product of labor.

The equilibrium price system is dependent on past policy and expectations of future policy, remittances, and uncertainty. The price level is dependent on the choice of money balances during the previous period which is a result of the cash-in-advance specification. Consequently, the choice of money growth in period t by the government affects the price level in period t and in period $t+1$. The interest rate in period t is a function of the expectation over future government policy, remittances, and labor supply decisions in period $t+1$ since the interest rate applied to the stock of bonds chosen by the household in period t will not be available for use again until period $t+1$.

The stochastic monetary economy contains a loss function via the presence of nonlinearities in the labor supply equation since the contemporaneous tax on labor income and money growth result in direct changes to household labor supply and additional indirect effects through remittances and endogenous changes in the marginal product of labor.[13] Taken together, the direct and indirect effects jointly determine optimal household labor supply.[14] Variations in government policy directly affect labor supply, output, remittances, remaining household allocations, and the equilibrium price system while feeding back into the government budget constraint through tax revenue. In addition, the shocks to technology and government spending cause changes in remittances and induce responses by both households and the government, thereby determining the overall volatility of the model economy. Equilibrium decisions by households, firms, the government, and remitters are then transmitted across time through the price level and interest rate. Thus, while optimal labor supply is only based on contemporaneous variables, the price system embeds expectations over the future path of remittances, policy, and the possible realizations of government spending and technology shocks. The degree to which changes in remittances, government policy, or exogenous shocks offset or magnify distortionary effects on equilibrium allocations depends on the degree of countercyclicality of remittances and the amount of nonlinearity present within the system, and within the labor supply function in particular.

IV. The Ramsey Equilibrium with Remittances

The goal of the government is to maximize the welfare of the household subject to raising

[13] The preservation of nonlinearities in the labor supply equation (17) endogenizes the assumption of a loss function over distortionary taxes and inflation as discussed in Barro (1979), Barro and Gordon (1981), Bohn (1988), and Schmitt-Grohé and Uribe (2004). These authors use a quadratic loss function to capture the excess burden of taxes and allocative distortions of inflation.

[14] While debt is not explicitly present in the labor supply function, it still plays a role since the choices of taxes and money determine the level of debt as a residual in the government budget constraint.

revenues through distortionary means. After the shocks to the system are revealed, the government selects a policy profile and households respond with a set of allocations. The resulting equilibrium determines the state variables for the next period. Therefore, when choosing an optimal policy mix, the government must take into account the equilibrium reactions by households, remitters, and firms to the chosen policy mix. The government is also constrained in its policy choices since it must choose a policy mix to maximize household utility while satisfying the government budget constraint. The following definition describes the Ramsey equilibrium with remittances.

Definition 1. A *feasible allocation* is a sequence of $\{C_{1t}\}_{t=1}^{\infty}$, $\{C_{2t}\}_{t=1}^{\infty}$, $\{H_t\}_{t=1}^{\infty}$, $\{G_t\}_{t=1}^{\infty}$ that satisfy the resource constraint in (12). A *price system* is a set of nonnegative bounded sequences $\{P_t\}_{t=1}^{\infty}$ and $\{R_t\}_{t=1}^{\infty}$. A *government policy* is a set of sequences $\{\tau_t\}_{t=1}^{\infty}$, $\{M_{t+1}\}_{t=1}^{\infty}$, $\{B_{t+1}\}_{t=1}^{\infty}$.

Definition 2. Given the exogenous sequences $\{g_t\}_{t=1}^{\infty}$ and $\{\theta_t\}_{t=1}^{\infty}$; initial stocks of money and bonds; and $M_0 = M_0^d$; a *competitive equilibrium* is a feasible allocation, a price system, and a government policy such that (a) given the price system and government policy, the allocation solves both the firm's problem and the household's problem; and (b) given the allocation and price system, the government policy satisfies the sequence of government budget constraints.

Definition 3. The *Ramsey problem* is to choose a competitive equilibrium that maximizes household utility. The competitive equilibrium that solves the Ramsey problem is called the *Ramsey plan* or *Ramsey equilibrium*.

A. The Ramsey Problem

Under the assumption that an institution or commitment technology exists through which the government can bind itself to a particular sequence of policies, the government attempts to maximize household utility in (4) subject to the government budget constraint in (8) while taking into account the equilibrium specification for the price system and optimal responses by households and firms.[15] After the shocks to spending and technology are realized, optimal policy is a mapping of state variables to labor taxes, money supply, and the amount of debt so that the government's budget constraint is satisfied. Like the

[15] The Ramsey problem in the general equilibrium dynamic programming setting incorporates many of the reputational mechanisms for credible government policies as discussed in Ljungqvist and Sargent (2000). In general, the government would find it optimal to deviate from its original set of policies if allowed, and some mechanism, reputational or otherwise, is needed to ensure credibility of government policy.

household maximization problem, the government's problem can be set up as a dynamic programming problem whereby the government seeks to maximize,

$$V(s_t) = \underset{\Delta_t}{Max} \left\{ \begin{array}{c} a\log C_{1t} + (1-a)C_{2t} - \gamma H_t + \\ \lambda_{gt}\left(\tau_t \alpha (Y_t - X) - G_t + B_{t+1} + \frac{M_{t+1}}{P_t} - \frac{M_t}{P_t} - B_t R_{t-1}\right) + \beta E_t V(s_{t+1}) \end{array} \right\} \tag{18}$$

where $\Delta_t = (\tau_t,\, \mu_{t+1},\, B_{t+1})$ is the set of choice variables, s_t represents the set of state variables $\left(B_t,\, M_t^d/P_{t-1},\, \theta_{t-1},\, g_{t-1},\, \tau_{t-1},\, R_{t-1}\right)$, and λ_{gt} is the Lagrange multiplier on the government budget constraint. The first-order conditions for the Ramsey problem are,[16]

$$\tau_t \;:\; \left\{ \begin{array}{c} \frac{a}{C_{1t}}\frac{\partial C_{1t}}{\partial \tau_t} + \frac{1-a}{C_{2t}}\frac{\partial C_{2t}}{\partial \tau_t} - \gamma \frac{\partial H_t}{\partial \tau_t} + \\ \lambda_{gt}\left[\alpha \tau_t \frac{\partial Y_t}{\partial \tau_t} + \alpha (Y_t - X) - B_t \frac{\partial R_{t-1}}{\partial \tau_t} - \left(\exp(\mu_{t+1}) - 1\right)\frac{M_t}{P_t}\frac{1}{P_t}\frac{\partial P_t}{\partial \tau_t}\right] \end{array} \right\} =$$
$$\beta E_t \left\{ \lambda_{gt+1} B_{t+1} \frac{\partial R_t}{\partial \tau_t} \right\}, \tag{19}$$

$$\mu_{t+1} \;:\; \left\{ \begin{array}{c} \frac{a}{C_{1t}}\frac{\partial C_{1t}}{\partial \mu_{t+1}} + \frac{1-a}{C_{2t}}\frac{\partial C_{2t}}{\partial \mu_{t+1}} - \gamma \frac{\partial H_t}{\partial \mu_{t+1}} + \\ \lambda_{gt}\left[\alpha \tau_t \frac{Y_t}{\partial \mu_{t+1}} - \frac{M_{t+1}}{P_t}\exp(\mu_{t+1}) - B_t \frac{\partial R_{t-1}}{\partial \mu_{t+1}} - \left(\exp(\mu_{t+1}) - 1\right)\frac{M_t}{P_t}\frac{1}{P_t}\frac{\partial P_t}{\partial \mu_{t+1}}\right] \end{array} \right\} =$$
$$\beta E_t \left\{ \lambda_{gt+1} B_{t+1} \frac{\partial R_t}{\partial \mu_{t+1}} \right\}, \tag{20}$$

$$B_{t+1} : \lambda_{gt} = \beta E_t \left\{ \lambda_{gt+1} R_t \right\}, \tag{21}$$

where λ_{gt} represents the marginal utility of relaxing the government budget constraint by one unit or, as suggested by Bohn (1988), the value that households place on the ability of the government to raise revenue from a source "outside" the economy. Such an ability would be equivalent to collection of a lump-sum tax, making the multiplier equal to the cost of distortionary government revenue policies.

Equations (19) and (20) reveal the importance of maintaining the endogeneity of the nonlinear labor supply function when examining the relationship between government policy and remittances. The impact of labor taxes and money growth on household welfare include both the direct effects of changes in government policy on labor supply and the indirect effects through changes in the endogenous marginal product of labor. For example, $\frac{\partial C_1}{\partial \tau} = \left(\frac{\partial C_1}{\partial Y}\frac{\partial Y}{\partial H} + \frac{\partial C_1}{\partial Rem}\frac{\partial Rem}{\partial Y}\frac{\partial Y}{\partial H}\right)\frac{\partial H}{\partial \tau}$. The direct effect of policy on labor supply is contained in $\partial H/\partial \tau$ and the indirect effect of policy on output and remittances is contained in the

[16] The first-order condition for money shown here is actually $\partial/\partial\left(\exp(-\mu_{t+1})\right)$. This was done for simplicity of computation. The optimal government policy for money balances can then be found by taking the $-\log(x)$ of the result.

parenthetical term. Therefore, an accurate assessment of the relationship between remittances, government policy, and household decisions requires a solution procedure that captures these direct and indirect effects. Preserving the endogenous properties of the marginal product of labor is also important in the determination of the variances and covariances of the model economies during simulation.[17]

The Euler condition in (19) describes the trade-off between taxation and issuing debt. The first terms on the left-hand side reflect the changes in consumption of the cash and credit goods and provision of labor by the household from a change in taxes. A change in the tax rate enters consumption of the cash and credit good indirectly via the equilibrium labor condition, which includes the impact of remittances. The bracketed term in (19) describes the change in the government budget constraint from a change in taxes scaled by the multiplier. The first terms inside the bracket represent the direct change in tax revenue from a change in tax policy, the sign of which depends on the nonlinear response of labor supply to a change in taxes. The remaining terms result from the commitment technology and the price effect on nominal money balances. These combined effects must be equal to the alternative policy of issuing additional debt which matures in the next period.

The trade-off between issuing money and debt is more complicated since money enters (20) directly through the money growth term and indirectly through the equilibrium labor condition. The first terms on the left-hand side detail the effects of money growth on consumption and labor supply, which depend on the net effect of money growth on output and consumption versus money growth on remittances. The bracketed term, as in the tax condition, details the impact of changes in money on the government budget constraint scaled by the multiplier, including the price effect on nominal variables. The first term describes the change in labor tax revenue based on the change in equilibrium labor from changes in money growth. These combined effects on the left-hand side must be equal to the alternative policy of issuing debt which matures during the next period.

B. Calibration and Solution Procedure

The system of equations that characterize the optimal policies in the Ramsey equilibrium theoretically is nonlinear. Therefore, the system is characterized quantitatively by assigning values to the parameters of technology, spending, preferences, and policy variables. Since the baseline economy contains no remittances, the process begins by calibrating the model to a non-remittance-dependent economy. In this case, the model is calibrated to match the

[17]The use of linear labor supply and resulting exogenous indirect effects, as in Aiyagari and others (2002), Alvarez, Kehoe, and Neumeyer (2004), and Schmitt-Grohé and Uríbe (2004), eliminates an important channel for optimal household decision making and the evaluation of the relationship between distortionary government policy and remittances.

general features of the post-Korean War U.S. economy as reported in the U.S. National Income and Product Accounts (NIPA).[18] Though the United States is the largest source country of remittance flows, with $39 billion in outward remittances in 2004 (World Bank, 2006), this total amounts to only 0.3 percent of GDP. Furthermore, a robust examination of business cycle properties of the U.S. economy is readily available for comparison purposes (e.g., Cooley and Prescott, 1995; and Stock and Watson, 1999). The NIPA data is used to derive parameter values for the share of income attributable to capital and labor, the capital-output ratio, the fraction of time households spend working in the market, the relative importance of the cash good versus the credit good in the utility function, technology and spending shocks, and the ratio of government spending to output.[19] The parameter values are summarized in Table 1. Using quarterly data from 1990:1–2002:4 the ratio of government spending to net national product was 18 percent and the ratio of federal government debt held by the public to net national product was 49 percent.[20]

The parameter describing the sensitivity of remittances to the business cycle is calibrated based on the literature on bequest behavior found in the United States. Like remittances, bequests are private income transfers and altruism is a key motive that explains bequest behavior (see Barro, 1974; and Becker, 1974).[21] Altruism implies that parents bequeath in a compensatory fashion since they receive utility from the lifetime resources of their children. A second implication of altruism is that parents will bequeath unequally, transferring more to children with fewer resources. Consequently, compensatory bequest behavior mirrors the countercyclical remittance function in this paper and the empirical findings from the bequest literature can inform the calibration procedure. In this regard, Wilhelm (1996) uses data from the Estate-Income Tax Match data set to test several altruistic models of optimal bequest behavior and finds that a $1 increase in earnings of the dependent results in a reduction in bequests of between $0.12 and $0.19, depending on the bequest function tested.[22] Based on the results of this study, the sensitivity of remittances

[18] This was done following the process in Stock and Watson (1999), Cooley and Prescott (1995), Cooley and Hansen (1991, 1995), Hansen and Wright (1992), Christiano and Eichenbaum (1992), Chari, Christiano, and Kehoe (1991, 1994), Juster and Stafford (1991), and Hansen (1985).

[19] A gross capital concept is assumed so that investment includes government investment. Government spending is defined as net real government spending on goods and services, or real total government spending less the sum of real defense investment, real non-defense investment, and real state and local investment. This amount is then taken as a ratio of real net national product.

[20] The results in this paper were also solved and simulated under twice the current U.S. debt-to-GDP ratio. The results were nearly identical to those presented here, suggesting the business cycle effects of remittances are largely invariant to initial calibrated debt levels. However, as discussed below, the presence of remittances lowers the marginal cost of government policy, meaning that additional debt may be easier to carry.

[21] For arguments in favor of exchange-motivated bequests see Bernheim, Shleifer and Summers (1985). See Perozek (1998) for a critique of the evidence on exchange motivation.

[22] The Estate-Income Tax Match data set is especially useful since it contains reliable information on both parents and heirs. The data set contains complete family information, matched by taxpayer identification

to the business cycle is set at $r_1 = 0.5$, meaning that remittances, like bequests, are compensatory on less than a one-to-one basis relative to output. In other words, a one unit increase in real income relative to steady-state income results in a decline in remittances of 0.05 units in equation (5). Our measure of the sensitivity of remittances to the business cycle is therefore conservative, as the response is only about one-third to one-half that suggested by the altruistic bequest literature. Increasing this parameter would generally magnify the business cycle results found herein, while a lower parameter value would dampen the reported results.[23]

The steady-state level of remittances, r_0, is varied from 5 to 30 percent of income during the solution and simulation procedure. This range was chosen to match data on mean worker remittances in percent of GDP for remittance-dependent economies as presented in Figure 1, and in other recent studies examining remittance flows such as World Bank (2006), Chami, Fullenkamp, and Jahjah (2003, 2005), Giuliano and Ruiz-Arranz (2005), and IMF (2005b). Thus, this range accurately describes the level of remittances found in what can be classified as "remittance-dependent" economies. Finally, the remaining variables, γ and δ, are derived from first-order conditions and the non-stochastic steady-state government budget constraint.[24]

The computational solution procedure is based on the projection approach as described by Judd (1992, 1998) and applied to Ramsey problems in Cosimano and Gapen (2005). The set of Euler conditions from the Ramsey problem, the labor equation from the household's problem, and the government budget constraint yield a set of four operator equations $N(f)$ that define the Ramsey equilibrium with remittances. Since the set of operator equations is nonlinear, the projection approach begins by defining the policy functions in terms of polynomials. In this case, Chebyshev polynomials are used. The solution

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numbers, and includes a variety of information in addition to income which is useful in controlling for non-income related factors. See Wilhelm (1996) for additional information.

[23] Another means of varying the sensitivity of remittances to the business cycle would be to alter the functional form in equation (5). For example, Wilhelm (1996) tests several models of altruistic bequest motives based on a linear specification, with the equivalent representation here similar to,

$$Rem_t = r_0 + r_1(\overline{Y} - Y_t),$$

with r_0 defined as the steady-state level of remittances and r_1 defined as in the text.

[24] The non-stochastic steady-state values for taxes and depreciation used to calibrate the disutility of labor are based on historical U.S. data, including the debt-to-income ratio. Re-calibration of the model under various levels of debt or remittances would result in different non-stochastic steady-state values for labor taxes and, in turn, the rate of depreciation and disutility of labor. In order to simulate each economy using constant household preferences, and therefore a constant baseline of preference parameters, the calibrated levels of γ and δ are held constant at their U.S.-based levels without remittances across all model economies in this analysis.

procedure solves for the optimal set of policies (H_t, μ_{t+1}, τ_t, λ_{gt}) as functions of the exogenous shocks and state variables that set $N(f) = 0$ simultaneously and satisfy the Ramsey equilibrium.[25] Since the state vector is comprised of information known to all parties at the beginning of the period, the procedure can be viewed as choosing policy functions based on newly revealed information, namely the exogenous shocks to technology and government spending, such that Euler and transversality conditions are satisfied.

The advantage of this approach is that the multiplier from the Ramsey problem, λ_g, is optimally solved for as an endogenous policy variable. Since the projection method is designed to capture higher moments, this process will more accurately illustrate the properties of the multiplier, the value of remittances, and the cost of distortionary government policy. Consequently, the solution method applied in this paper differs from other recent studies that use a simplified production function (Aiyagari and others, 2002; Alvarez, Kehoe, and Neumeyer, 2004; and Schmitt-Grohé and Uribe, 2004) or employ the more traditional primal approach (Chari, Christiano, and Kehoe, 1994; and Chari and Kehoe, 1999).[26] Once properly specified, the system is solved using a nonlinear equation optimizer in Matlab. The results of this procedure are discussed in the next section.

V. RESULTS

The Ramsey problem was solved in economies with and without remittances. The baseline economy contains no remittances. When remittances are present, the solution was derived under various remittance-to-income ratios, ranging from 5 to 30 percent. Then using the optimal coefficients of the polynomial approximations that describe the Ramsey plan, each economy was simulated under the effects of technology and government spending shocks.

[25] The boundaries of the space defining the exogenous technology and government spending shocks are calibrated from actual U.S. data. The interval for each is taken as a multiple of the standard deviation of the error process. Chebyshev collocation methods divide the state space over θ and g into discrete grid points, where higher numbers of points produce a more defined grid space for which the system is solved over. The set of residual functions also contain conditional expectations which must be evaluated. Since the processes that govern the shocks to technology and government spending are assumed to be distributed $N(0, \sigma^2_{\theta,g})$, expectations can be evaluated using Gauss-Hermite Quadrature. In this procedure, the form of the policy function is assumed to be independent of the realization of the shocks. Expectations are found by integrating over the possible realizations of θ and g while treating the policy function as a constant.

[26] The primal approach recasts the problem of choosing optimal policy as a problem of choosing allocations subject to constraints which capture restrictions on those allocations. In practice this means using an infinite horizon budget constraint with prices and policy substituted out using first-order conditions, commonly referred to as the implementability constraint. The use of the implementability constraint often requires a search procedure that iterates across candidate solutions for the multiplier (Chari, Christiano, and Eichenbaum, 1994) as opposed to endogenously solving for the multiplier as is done in this paper. Furthermore, the multiplier on the implementability constraint has a different interpretation than the multiplier in this paper.

Statistics were computed by running multiple simulations of 5000 periods in length, taking logarithms, and filtering each simulated time series using the H-P filter as described in Hodrick and Prescott (1997).

A. Steady-State Decision Rules with Remittances

The upper panel in Table 2 represents the steady-state Ramsey equilibrium in levels or growth rates. In the baseline economy without remittances, optimal government policy follows the Friedman rule by setting money growth equal to the rate of time preference.[27] In this case, the Friedman rule results in an expected gross nominal interest rate equal to 1.0 and the expected real return on money balances is equal to the inverse of time preference in the steady state.[28] In other words, the government equates the real gross rate of return on money balances and government debt in expectation, satisfying Euler conditions. As discussed in Alvarez, Kehoe, and Neumeyer (2004) and Chari, Christiano, and Kehoe (1991, 1996), the Friedman rule is optimal in a variety of monetary economies with distortionary taxes. That the government should avoid taxation of intermediate goods, in this case money balances, is also a well established result from public finance (e.g., Diamond and Mirrlees, 1971). Enacting the Friedman rule requires the government to run a gross-of-interest surplus by setting equilibrium labor income taxes high enough to cover government spending, interest on the debt, and the withdrawal of money balances from the economy.

The existence of remittances provides the household with additional disposable income, and the household spreads these resources over each of the consumption goods as well as leisure. Consequently, as remittances are added to the model economies, steady-state consumption of the cash and credit goods increases while steady-state labor supply decreases. For example, Table 2 reports a decline in steady-state labor supply from 0.31 to 0.29, a decline of more than 6 percent, in the economy with a 5 percent remittance-to-income ratio. As the remittance-to-income ratio rises to 30 percent, steady-state labor supply declines by nearly a third and output falls by nearly 20 percent. Despite the decline in output as a result of lower steady-state labor supply, the household is able to increase overall consumption since disposable income – income from production plus remittances – has risen (Table 2).

[27] According to Friedman (1969), optimal monetary policy satiates the economy with real balances to the extent that it is possible to do so.

[28] If the models in this paper included nominal government debt, the equilibrium nominal interest rate would be equal to,

$$R_t^N = \frac{1}{\beta} \frac{1}{E_t \left[\exp -(\mu_{t+2}) \right]},$$

which would equal 1.0 if money supply grew at the rate of time preference, β.

As a result of adding remittances and their effect on labor supply and domestic output, optimal government policy responds by increasing steady-state taxes and money growth in order to finance the same level of government spending and debt. The steady-state tax rate increases from 18.8 percent in the economy without remittances to 21.1 percent under a remittances-to-income ratio of 30 percent. Over the same interval, the steady-state money growth rate increases to 6 percent per quarter, indicating that optimal monetary policy deviates from the Friedman rule in the presence of remittances. Following the recent survey by Kocherlakota (2005), non-optimality of the Friedman rule in a representative agent model with flexible prices is unusual. Reasons for the departure will be discussed more fully in the following sections. As these distortionary policy levers are increased, the cost of government policy increases at the margin, which would otherwise induce a further decline in steady-state labor supply in addition to the effect on labor from remittances. However, the presence of remittances insulates the household from distortionary government policy by providing a countercyclical source of income that government policy cannot act upon directly. This is reflected through a lower value of the multiplier on the government budget constraint, which falls by nearly one-third as remittances are introduced. Although the government needs to increase revenues through higher distortionary taxation and money growth, the household is better able to absorb the additional distortion this policy generates since fiscal and monetary policy act on a smaller portion of disposable income in the presence of remittances.

B. Remittances and Business Cycle Moments

The bottom panel in Table 2 reports summary statistics on the moments of the business cycle for each model economy. As is commonly found in most real business cycle models, the model without remittances generates about half of the standard deviation of output as found in the U.S. economy.[29] The model economy without remittances generates volatility of consumption, prices, and inflation that more closely match features of U.S. data as reported in Stock and Watson (1999) and Cooley and Prescott (1995). Although money supply has very little volatility in the economy without remittances, volatility of the price level and rate of inflation in each period are also determined by volatility of the cash good due to the cash-in-advance specification. The volatility of the interest rates is lower than that found in other studies since the values reported here are based on the filtered value of the gross interest rate series as opposed to a series of net interest rates. For reasons discussed in the subsequent sections, however, the economies with remittances begin to approach the level of volatility found in the U.S. economy.

[29] Stock and Watson (1999) report standard deviation of real GDP of 1.66 (from 1953–1996) and Cooley and Prescott (1995) report standard deviation of real GNP of 1.72 percent (from 1954:1–1991:2). Some of the reduced model volatility is due to the assumption of a fixed capital stock since standard deviation of investment is much higher than output and consumption.

The properties of each variable under each of the model simulations are displayed in Tables 3 – 6. Table 3 contains the cross-correlation of each variable with output, government policy, and exogenous shocks for the economy without remittances and Tables 4 – 6 display the results with remittances. The model economy without remittances produces a negative correlation between labor and output, which stands in conflict with actual U.S. data.[30] The negative correlation is a direct result of the assumption of a fixed capital stock, eliminating the complementary inputs characteristic of the production function.

The Baseline Economy without Remittances

This section details the response of government policy, household allocations, and price system to a positive one-period shock to technology and government spending in the economy without remittances. The impulse response functions are displayed in Figure 2.[31]

The equilibrium response of household labor supply to a productivity shock is determined by the combined effects of technology on the real wage, government policy, and the marginal utility of consumption. First, a positive shock to technology causes labor supply to increase through the direct effect higher technology has on labor supply through a higher real wage. The same increase in technology, however, also increases overall output. Since additional economywide resources are now available, government policymakers can reduce distortionary labor taxes and money growth and still finance the same level of government spending. This accounts for the negative correlation between technology shocks and fiscal and monetary policy in Table 3. The reduction in the labor tax rate and money supply have positive correlations with labor supply that reinforce the direct effect from a higher after-tax real wage since decreases in taxes and money growth increase labor supply. However, the increase in technology also decreases the marginal utility of consumption of the credit good, which otherwise causes a decrease in labor supply. Overall, these effects combine to produce a decline in labor supply.

In the baseline economy without remittances, a positive technology shock that causes a

[30] Cooley and Prescott (1995) report positive correlation between output and total hours of work and average weekly hours of work from using data from both the household survey and establishment survey.

[31] Each set of vertical panels in the figure reports the percentage deviation from steady-state values for the relevant variables under a positive one-standard deviation shock to technology (left vertical panels) and government spending (right vertical panels). The percentage deviation of real and nominal interest rates are based on gross rates. Deviation of money growth is based on the net money growth rate. The cross-correlations from the simulations in Tables 3 – 5 are based on filtered data as opposed to the impulse response functions which are based on raw data. The use of the H-P filter generally reduces the persistence of the various series (i.e., reduces the tendency for the variables to remain away from their steady-state values) and occasionally changes the sign of the initial response if the percentage deviation under raw data is very low. Nevertheless, this section proceeds with the standard use of raw data since the exercise remains illustrative of model relationships.

decline in labor supply in the first period from its steady-state value produces a positive correlation between labor supply and government policy and a negative correlation between labor supply and technology shocks, all of which are reported in Table 3. The household is able to spread the additional economywide resources across both consumption goods and increased leisure since output rises even though labor supply falls. The government is also able to use the additional resources to pay down debt, although the percent deviation from the steady-state level of debt is small. The reduction in distortionary labor taxes and monetary policy, along with slight declines in outstanding debt, result in a lower value for the multiplier on the government budget constraint. In a situation where additional economywide resources are available, the marginal cost of financing government spending has been reduced.

The effect of the positive shock to technology on prices is dependent on the change in the level of consumption of the cash good since the price level is determined through the cash-in-advance constraint which holds with equality in equilibrium. In this case, a higher level of cash good consumption lowers the period t price level relative to its steady-state value since nominal money balances were chosen during period $t-1$ for use in period t. However, in periods $t+1$ onward the positive technology shock results in higher inflation relative to steady-state values since consumption of the cash good begins to return to its steady-state level, or $C_{1t+i+1} < C_{1t+i}$, and offsets the lower money growth rate. Consequently, the inflation dynamics in response to a positive technology shock first result in lower inflation in the initial period of the shock and then slightly higher inflation relative to steady-state inflation as the shock begins to expire. The real interest rate falls in period t since the expected marginal value of consumption of the credit good in period $t+1$ is less than the level that prevails in period t as a result of the technology shock. The path that consumption of the credit good takes in return to the steady state, combined with Jensen's inequality effects, results in a decline in real interest rates.

A positive shock to government spending is displayed in the right column of Figure 2. In this case, the shock causes labor supply to decrease through the direct effect of higher taxes on labor supply through a lower after-tax real wage. The increase in labor taxes, money growth, and debt occur since policymakers need to finance the additional government spending, resulting in a positive correlation between government spending and labor taxes, money growth, and debt in the both panels of Table 3. The increase in the labor tax rate and money supply have a negative effect on labor supply that reinforces the direct effect from a lower after-tax real wage since increases in taxes and money growth decrease labor supply through the implicit function governing labor supply. However, the increase in government spending also increases the marginal utility of consumption of the credit good, which otherwise induces an increase in labor supply. In the baseline economy without remittances, these effects are largely offsetting, causing negligible declines in labor supply and output. The resulting lack of correlation between shocks to government spending and

both labor supply and output in the baseline economy without remittances are reflected in Table 3.

Since output remains essentially flat, the increased government spending pulls economywide resources away from the household, resulting in reduced consumption of both cash and credit goods while leisure remains relatively unchanged. The increase in distortionary labor taxes and money growth, along with slight increases in outstanding debt, result in a higher value for the multiplier on the government budget constraint. In a situation where additional government spending makes claims on an unchanged amount of economywide resources, the marginal cost of financing government spending has increased. This is reflected in a higher value of the multiplier on the government budget constraint which increases 3 percent from its steady-state level in the same period as the positive shock to government spending is revealed.

The positive shock to government spending displays the expected positive relationship on prices. A lower level of consumption of the cash good increases the period t price level since nominal money balances have already been chosen during the previous period. In contrast to the positive technology shock, inflation remains above its steady-state level while the government spending shock persists. From period $t+1$ onward, $C_{1t+i+1} > C_{1t+i}$ which otherwise reduces inflation, but this effect is offset by higher money growth leaving inflation slightly above steady-state inflation for the duration of the government spending shock. The interest rate increases in period t since the expected value of consumption of the credit good in period $t+1$ is more than the level that prevails in period t as consumption begins to return to steady-state levels.

The Economies with Remittances

The response of government policy, household allocations, and price system to a positive one-period shock to technology and government spending in the economies with remittances is displayed in Figure 3 and Tables 4 – 6. The main difference between the economies with remittances and the economy without remittances is the changing relationship between labor and domestic output in the presence of remittances. As remittances are added, the magnitude of the negative correlation between labor supply and output is reduced. Under 5 percent remittances to income, the correlation falls from -1 to -0.92. At the 15 percent level of remittances to income, the correlation between labor supply and output changes sign with the correlation registering 0.50. Finally, at a remittances-to-income ratio of 30 percent, the correlation between labor and output approaches 1.0, a near complete reversal from the economy without remittances.

The simulation results indicate that, for the economy without remittances, a positive technology shock will lead to higher output, but will induce households to lower their labor

supply. When remittances are present, however, a positive technology shock that raises output will lead to lower remittances – the latter being due to the countercyclicality of these flows. Lower remittances induce the household to raise its labor supply, which will offset the household's tendency to lower its labor supply due to the positive technology shock. The changing correlation merely signals that the household is deciding optimal labor supply based on both domestic economic conditions and remittances, with household labor supply becoming more sensitive to remittances as the level of remittances to income is increased. Consequently, while remittances are explicitly modeled as countercyclical income transfers, their effect on output is procyclical. Though not reported in Tables 4 – 6, simulations indicate that the sign change on the correlation between labor and output takes place at a remittances-to-income ratio of around 8 percent. Thus, a relatively low level of remittances to income can meaningfully alter the economic relationships in the economy, a level which is being seen with increasing frequency in many countries (Figure 1).

Figure 3 details the impulse response functions from a one-period shock to technology and government spending under 15 percent remittances to income. Relative to the baseline economy without remittances, the response of labor supply to a one-period positive technology shock is now positive, producing a stronger output response. In particular, output rises by 0.74 percent with remittances in Figure 3 versus 0.61 percent without remittances in Figure 2. Remittances, however, fall due to their countercyclical nature, leaving the response of household consumption at similar levels as the economy without remittances. Consumption in the economy with remittances increases by 0.91 percent versus an increase of 0.93 percent in the baseline economy without remittances. The effect of remittances on government policy is somewhat mixed, as the positive technology shock results in a more pronounced drop in money growth and a smaller reduction in labor taxes. Finally, in contrast to the baseline economy without remittances, the inflation rate remains below the steady-state level while the positive technology shock persists. This is due to the strong negative response of money growth in the presence of remittances, which in this case is nearly twice as strong as found in the baseline case.

In response to a positive one-period shock to government spending, the labor supply response is now clearly negative, producing a stronger decline in output relative to the baseline economy without remittances. Labor and output decline by -0.09 percent and -0.05 percent, respectively, in the economy with 15 percent remittances to income in Figure 3, versus the flat response shown in Figure 2. The stronger decline in labor supply and output means the government has a smaller base of resources to finance the same positive government spending shock as in the baseline case, and so it chooses slightly more money growth and debt relative to labor taxes to finance this additional spending. As a result, consumption falls by more in the economy with remittances relative to the baseline economy without remittances. Finally, the response of inflation to the positive government spending shock is much stronger in the presence of remittances, increasing by 0.67 percent

under 15 percent remittances to income versus 0.50 percent in the baseline economy without remittances. The inflation rate remains well above the steady-state rate of inflation as the positive government spending shock persists.

Since the correlation between labor and output has changed signs in the presence of remittances, the correlation between labor and government policy has also changed signs. As can be seen from the simulation results in Tables 4 and 5, the correlation between labor supply and labor taxes and money growth has changed from 0.34 and 0.53, respectively, under no remittances to -0.99 and -0.95, respectively, under a 15 percent remittances-to-income ratio. In fact, the sign change takes place at a slightly lower level of remittances to income, as the correlation between labor supply and labor taxes is already negative at 5 percent remittances to income. Fiscal and monetary policy have a stronger negative correlation with output in the economies with remittances relative to the baseline economy without remittances. Therefore, while their impact on output is procyclical, remittances serve to increase the countercyclicality of government policy.

The changing correlations between (i) labor supply and output and (ii) labor supply and labor taxes in the presence of remittances are also behind the departure from optimality of the Friedman rule. As discussed in Alvarez, Kehoe, and Neumeyer (2004), the Friedman rule of setting net nominal interest rates to zero is optimal under commitment when the government has a sufficient number of independent policy instruments. In the baseline economy without remittances, the period $t-1$ government has a sufficient number of independent instruments to bind and control the choices of the period t government. By enacting the Friedman rule, the period $t-1$ satiates consumers with real balances and equalizes expected rates of return across bonds and money. The period $t-1$ government is left with real bonds to induce the period t government to follow the same plan.

In contrast, the addition of remittances causes a reduction in labor supply and output, meaning the government has to raise additional resources, and following the Friedman rule in this case would require higher steady-state labor taxes to cover government spending, interest on the debt, and the withdrawal of money balances. Yet the changed correlations between (i) labor supply and output and (ii) labor supply and labor taxes means following the Friedman rule would induce successive declines in labor supply and output, further increasing remittance flows and creating further market inefficiencies. In other words and in the spirit of Tinbergen (1956), the changing correlations of underlying economic variables in the presence of remittances means the government does not have a sufficient number of independent policy instruments to meet all of its objectives simultaneously. Consequently, the government finds it optimal to use its remaining policy instrument, the inflation tax or the nominal interest rate tax, as inflation is the return on nominal money balances, since the debt stock alone is not rich enough to adequately control the incentives of successive governments.

One important conclusion that can be drawn from non-optimality of the Friedman rule in the presence of remittances, therefore, is that the government needs to have a sufficiently rich set of government policy instruments to carry out its policy plans. Remittances and the need for instrument independence may be one reason why developing countries place a greater reliance on consumption-based taxation or implement financial transactions taxes like those found in Colombia, Ecuador, and Brazil, among others. A consumption tax, or value-added tax, may be a more appropriate policy instrument since the tax could counter the procyclical relationship between labor and output in the presence of remittances, providing more instrument independence relative to the labor income tax.

C. Remittances and Macroeconomic Risk

In the previous section, we detailed how the presence of remittances changes the sign of the correlation between labor and output from negative to positive as the household seeks to smooth consumption. Alteration of the relationship between labor and output is significant for a number of reasons. The surprising procyclical finding has the unsavory effect of increasing output risk, as seen by the increased volatility of output in the second panel in Table 2, and in Figure 4. Thus, remittances, while countercyclical, result in higher business cycle volatility. Moreover, the increase in output risk will also produce an increase in labor supply risk. Volatility of labor supply initially falls (Figure 4) as the correlation between labor and output remains negative, but below unity. As additional remittances are added, the correlation switches sign and the positive correlation begins to increase labor supply volatility. Under higher levels of remittances, household labor supply is responding to the combined effects of economic shocks on output and remittance flows, with the household reacting more forcefully to the changes in remittances as the remittances-to-income ratio increases. The increased volatility of labor supply will result in a more volatile process for real wages and lead to increased labor market risk and, although not explicitly modeled in this paper, will increase the importance of efficient wage contracting and risk-sharing between firms and households. This result is likely to be more pronounced when other distortions are introduced into the framework. For example, Chami and Fischer (2000) and Chami, Fullenkamp, and Jahjah (2003, 2005), in the context of asymmetric information, find that such private income flows increase labor market risk.[32]

The impact of remittances on household consumption can also be seen by examining Figure 4 and Table 2. First, remittances produce higher levels of disposable income and,

[32]Chami, Fullenkamp, and Jahjah (2003, 2005) introduce asymmetric information between the household and the firms and between the household and the remitter. They show that profit maximization by risk-netural firms, in this case, induces these firms to shift more risk to the households. They conclude that the optimal level of such transfers, which takes the firm's need to break even into consideration, would result in a lower level of transfers being chosen than in the decentralized case.

consequently, higher steady-state consumption of cash and credit goods. However, the countercyclical nature of remittances and their procyclical effect on output has offsetting effects on the variability of consumption, with volatility of the credit good declining and volatility of the cash good increasing. The ability of remittances to provide consumption insurance against shocks to household income therefore depends on the relative importance of the cash and credit good in household consumption. The countercyclical nature of remittances leads to an insurance effect on consumption of the credit good since remittances can be converted into the credit good in the same period the household receives the income transfer. Conversely, the cash-in-advance constraint means the household has to transfer remittance resources across time to consume the cash good and the more volatile inflation and output processes leads to increased volatility of cash good consumption. Since the calibrated values reported in Table 1 result in relative balance between the cash and credit good in household consumption, remittances are unable to reduce consumption volatility. Decreased volatility of credit good consumption is offset by increased volatility of cash good consumption, leaving overall consumption volatility unchanged.[33] That said, overall consumption volatility that remains constant in the face of increasing business cycle volatility allows us to conclude that remittances do have an insurance effect on consumption, if only to prevent consumption risk from increasing in line with economywide output risk.

Like household consumption, the countercyclical nature of remittances and their procyclical effect on output has varying consequences on the volatility of government policy. In the economy without remittances, nearly all the volatility in government policy appears in labor taxes, as the labor tax rate fluctuates to preserve the Friedman rule (Figure 4 and Table 2). As remittances are added, the volatility of the labor tax rate declines, mirroring and contributing to the declining volatility of consumption of the credit good. The presence of remittances increases the mean equilibrium growth rate of money and also increases its volatility. The increase in volatility of the money supply is a contributing factor to the increased volatility of the inflation process and consumption of the cash good. On balance, however, the cost of government policy appears to become more volatile as the standard deviation of the multiplier on the government budget constraint rises, contributing to an increase in policy risk.

D. Matching the Moments

While the goal of any real business cycle model is to match the moments of the model with actual data to examine the degree to which the model can explain observed economic

[33] Although not reported in Table 2, the standard deviation of total household consumption only falls from 1.37 percent in the economy without remittances to 1.34 percent under a 30 percent remittances-to-income ratio.

cycles, this exercise is largely beyond the scope of this paper due to the data intensiveness involved in such a cross-country study. The lack of available time series of the necessary data in remittance-dependent economies would likely preclude such an exercise. However, we are able to match some of the main theoretical results of the paper to observed data, and we report these results here. A preliminary examination of the data from the remittance-dependent economies in Figure 1, where available, appears to confirm the model results that economies with higher reliance on remittance flows may experience higher rates of inflation and output volatility. Figure 5 plots both the average inflation rate and standard deviation of output volatility in remittance-dependent economies, or countries with remittances to income of 5 percent or greater, during the period from 1990 to 2003. Both panels indicate that economies that recorded higher levels of remittances also experienced higher rates of inflation and output volatility, with the relationship between remittances and business cycle volatility appearing particularly strong. In the next section, we numerically examine whether the additional output volatility outweighs the benefits of higher consumption for the household.

E. Measuring the Gains

A certainty equivalence framework is used to measure the gain to households from remittances. The utility equivalence is measured as the per-period increase in utility that makes the household indifferent between the economy without remittances and the selected economy with remittances. The utility equivalence measure is derived from two components: the steady-state increases in consumption and leisure which increase utility versus the increase in business cycle volatility which will tend to decrease utility. The resulting gain or loss will depend on the net impact of the steady-state versus business cycle effects. The utility equivalent measures were computed for each variable that enters the household's utility function, thereby highlighting the contribution that each plays in utility gains. Values were taken from an average across a similar set of simulations for each calibrated economy and are displayed in Table 7. For example, the per period gain in utility from moving from the economy without remittances to the economy with 5 percent remittances to income is 4.7 percent. The increase in per period utility rises to 22.8 percent under 30 percent remittances to income.

The contribution to increases in per-period utility in order of importance are leisure, followed by consumption of the credit good, and lastly by consumption of the cash good which makes the smallest contribution. The cash-in-advance constraint limits the ability of the household to efficiently transfer remittances into consumption of the cash good, and the difference in welfare effects in Table 7 between the cash and credit goods can be interpreted as the cost of a higher and more volatile inflation process. This wedge is not present when the household converts remittances into consumption of the credit good and

leisure. Consequently, the household is better able to utilize the increase in household resources and the countercyclical properties of remittances by transforming them into contemporaneous consumption and leisure. Additional leisure represents nearly 60 percent of the overall increase in per period utility.

The gain in per period utility is mainly derived from the increased level effects in the steady-state. While volatility of the economies with remittances is larger than the economy without remittances, the cost of increased business cycle volatility is not sufficiently large enough to offset the steady-state level effects on consumption and leisure. The simulations indicate that the cost of increased business cycle volatility alone is equivalent to a present discounted value of -0.7 percent of *lifetime utility* from moving from the economy without remittances to the economy with a 5 percent remittances-to-income ratio. This cost of additional output volatility from remittances is roughly equivalent in magnitude to the the cost of the business cycle volatility as reported by Lucas (1987, pp. 20-31). This cost, however, is much smaller than the 4.7 percent increase in *per period* utility from the steady-state level effects on utility.

VI. CONCLUSION

Examination of external capital flows that are recorded in the capital account of the balance of payments has been the subject of much interest by economists and researchers, especially following the Asian financial crisis of the 1990s. While the right mix of policies to deal with volatile capital flows remains an open question, Calvo, Leiderman, and Reinhart (1996) conclude that the developing economies that were most successful in managing the swings in capital flows relied on a comprehensive package of policy choices, as opposed to over reliance on a single instrument. Highly volatile international capital flows and associated macroeconomic instability also caused many to question IMF policy recommendations and the role of the IMF in capital account liberalization. In particular, in the report on the IMF's approach to capital account liberalization, the Independent Evaluation Office of the IMF (IMF, 2005a, p. 5), concluded:

> In encouraging capital account liberalization, the IMF pointed out the risks inherent in an open capital account as well as the need for a sound financial system, even from the beginning. The problem was that these risks were insufficiently highlighted, and the recognition of the risks and preconditions did not translate into operational advice on pace and sequencing until later in the 1990s (and even thereafter the policy advice has often been of limited practical applicability).

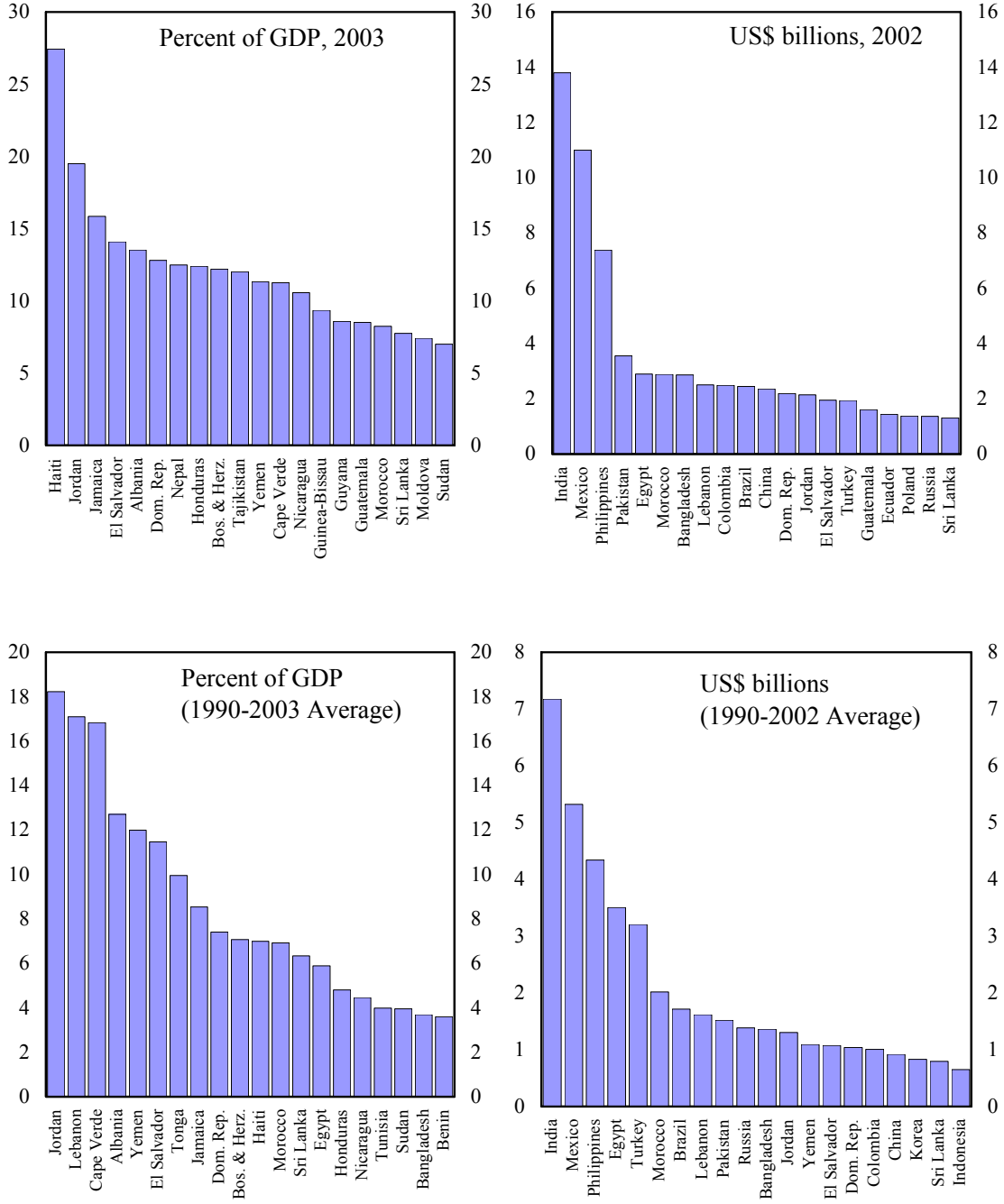
Remittances, which flow through the current account of the balance of payments, have not

received the same attention and careful scrutiny as private capital flows. In the absence of a framework that allows for a systematic analysis of the impact of remittances on the recipient economy, a positive aura has surrounded and colored the role of remittances and the policy prescription towards these flows. The conventional wisdom, with few exceptions, is that remittances: (i) represent a stable and reliable source of foreign exchange, (ii) reduce poverty, (iii) insure consumption against bad shocks, (iv) reduce macroeconomic volatility, (v) enhance investment in physical and human capital, and (vi) alleviate credit constraints. Consequently, there is a current emphasis among policymakers to highlight remittances as a potential cure to the many economic challenges facing developing countries that depend on such transfers. Without careful analysis of the macroeconomic implications of such transfers, policies aimed at encouraging remittances may create unintended consequences for the recipient economies.

This paper takes initial steps towards a unifying framework that assesses how remittances influence the incentives and decisions of economic agents, while also investigating how these decisions impact the recipient economy at large. The model applied is well grounded in the public finance and business cycle literature and relies on optimizing behavior by various agents in the economy. In this unifying framework we find that remittances, like private capital flows, have both positive and negative economic effects. While remittances increase consumption and have the ability to smooth household consumption against income shocks, they may also contribute to increased macroeconomic risk through higher business cycle volatility. The presence of remittances also changes the underlying relationship between labor and output, thereby changing the functioning of government policy instruments. If the set of policy instruments is not sufficiently varied, this may result in an increased reliance on the inflation tax.

We believe that the suggestion by Calvo, Leiderman, and Reinhart (1996) that government should examine a wider variety of policy instruments when dealing with private capital flows, should also apply to private income transfers such as remittances. We further encourage continued research into the macroeconomic effects of remittances, with particular emphasis on whether remittances entail additional economic and policy risk and, if so, to what degree. We believe that our framework is general enough to allow for the addition of other features that reflect particular institutional or country-specific factors. Finally, while it is unlikely that remittances entail the same level of risk as private capital flows since remittances are generally altruistically motivated, we nevertheless hope that the analysis presented here can help formulate a well reasoned set of policy instruments and operational guidance that can be provided to governments and policymakers faced with such flows.

Figure 1. Developing Countries: 20 Largest Recipients of Remittances



Source: International Financial Statistics (IFS) database. Remittances are defined in the broadest possible terms as the sum of migrant transfers, workers' remittances, and compensation of employees.

Figure 2. Impulse Response Functions: Baseline Economy without Remittances

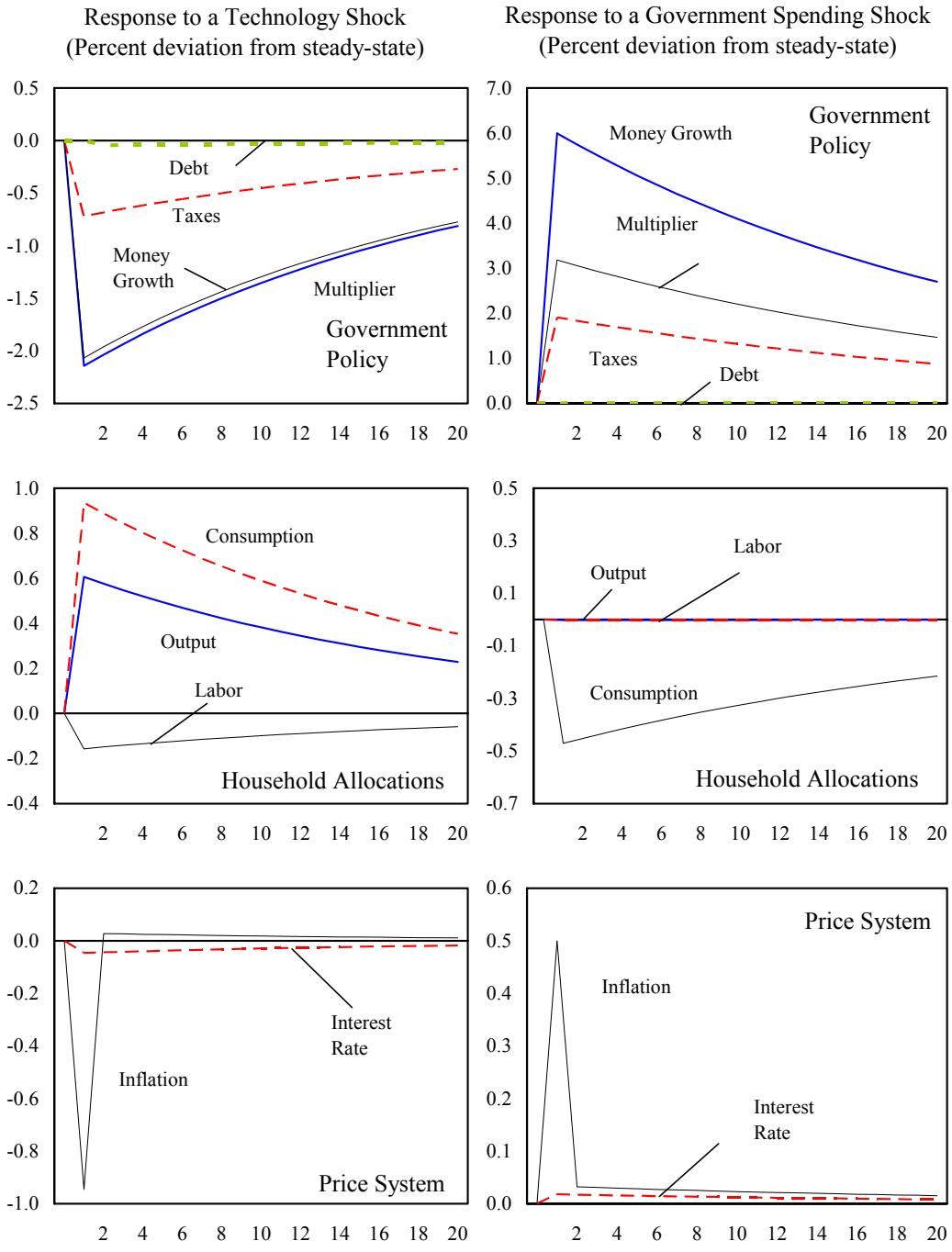


Figure 3. Impulse Response Functions: Economy with 15 Percent Remittances to Income

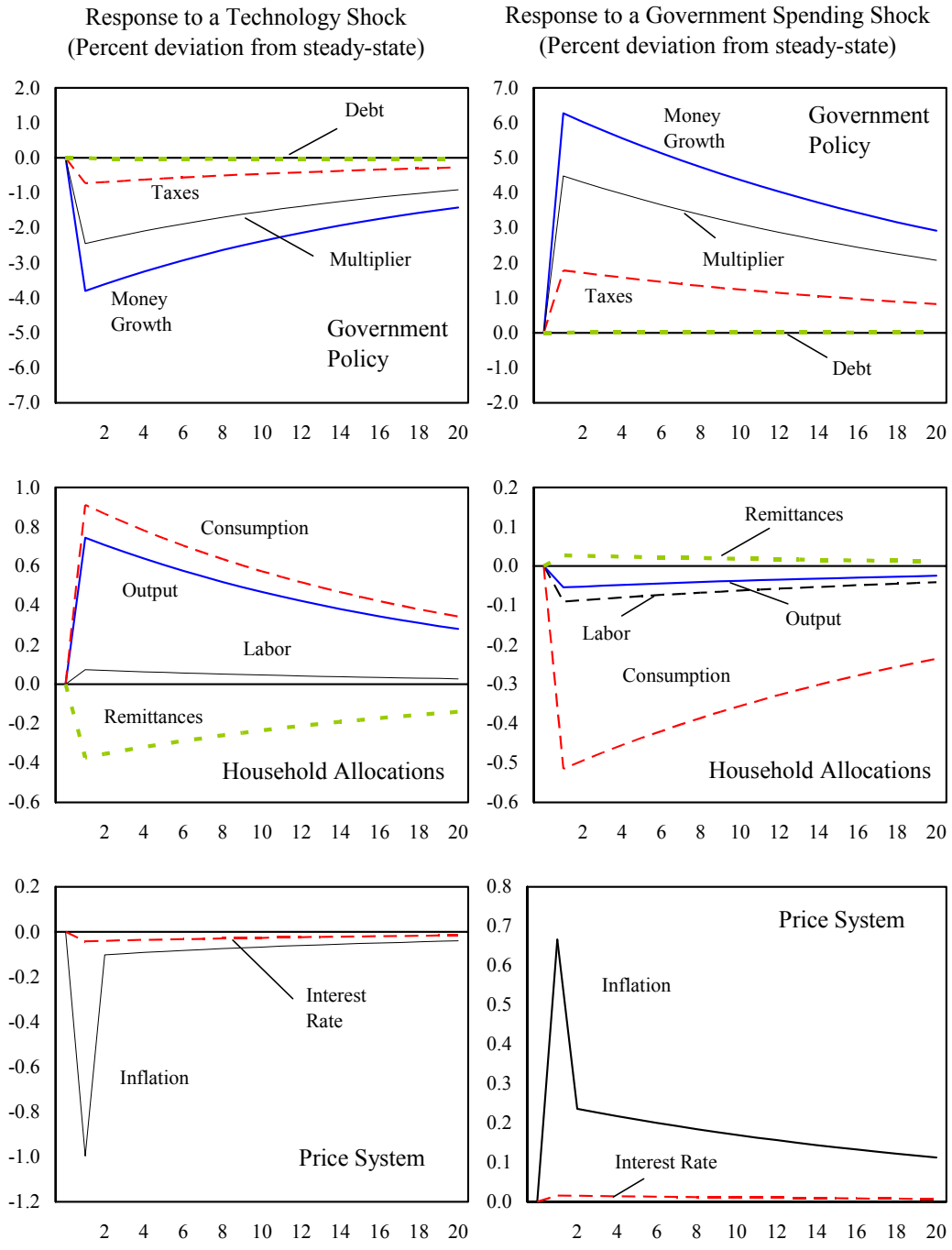
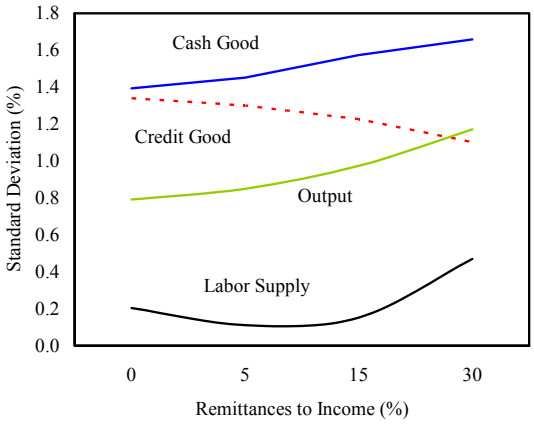
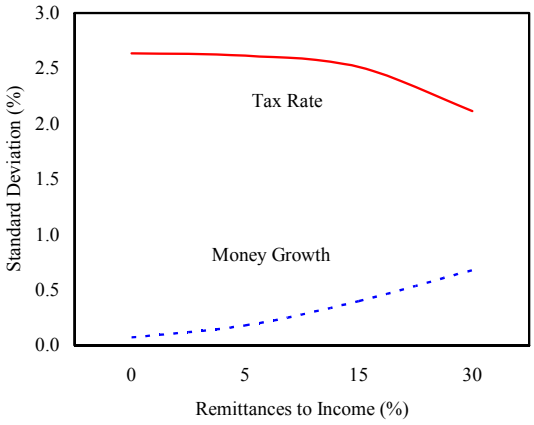


Figure 4. Remittances and Standard Deviation of Household Allocations, Government Policy, and the Price System





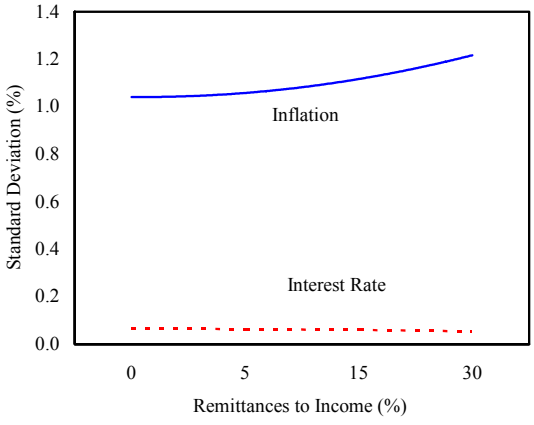
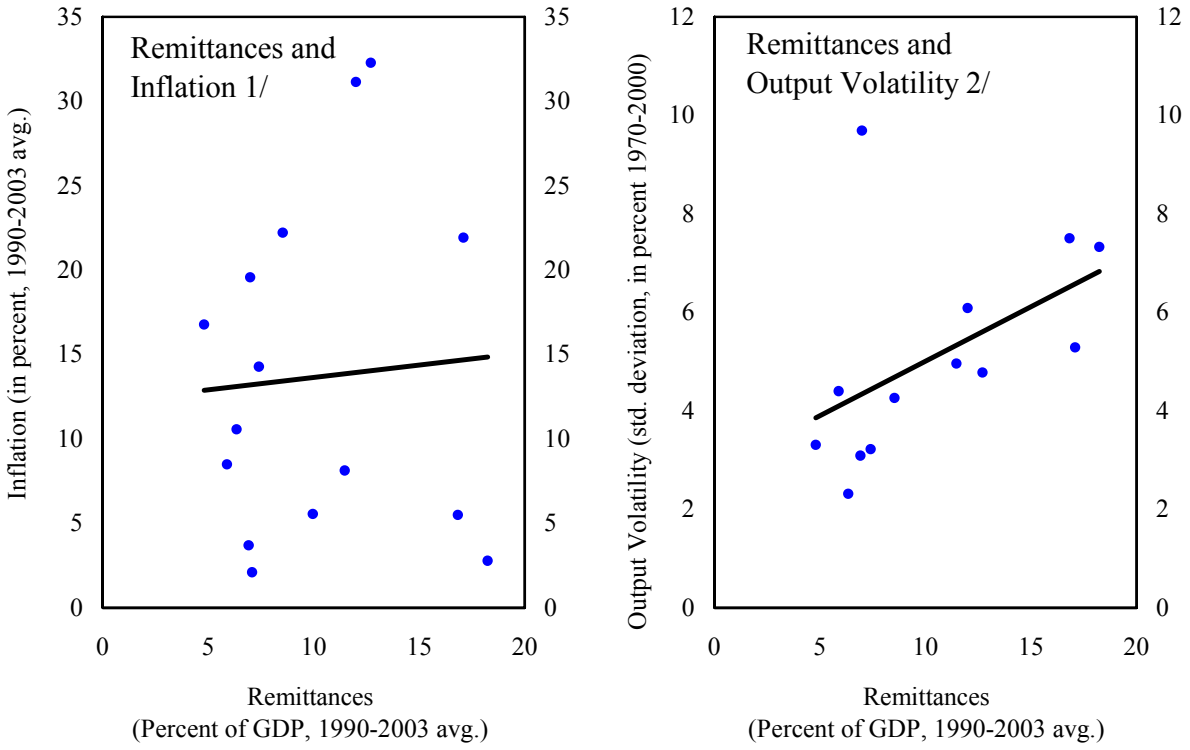


Figure 5. Top Remittance-Dependent Countries: Inflation and Output Volatility



1. Source: IFS database. Countries included were those with average annual remittances to GDP of 5% or greater during the period from 1990-2003, data where available.
2. Source: IFS database and Penn World Tables (Heston, Summers, and Aten, 2002). Countries included have average annual remittances to GDP of 5% or greater from 1990-2003, data where available. Volatility of output was calculated by detrending logged real GDP per capita from the Penn World Tables using the HP filter (Hodrick and Prescott, 1997), and then computing standard deviation of this filtered series.

Table 1. Parameter Values Corresponding to U.S. Economy

Parameter Values								
α	β	a	γ	δ	ρ_θ	σ_θ	ρ_g	σ_g
0.6	0.991	0.44	2.44	0.016	0.95	0.007	0.96	0.021

Table 2. Selected Simulations: Steady-State Values and Standard Deviations

Steady State Values					
	Remittances-to-Income Ratio				
Variable	0%	5%	10%	15%	30%
	(in levels)				
Output [1/]	1.734	1.667	1.607	1.551	1.406
Remittances	-	0.083	0.161	0.233	0.422
Cash Good	0.494	0.496	0.499	0.502	0.515
Credit Good	0.629	0.644	0.658	0.671	0.702
Labor	0.309	0.289	0.272	0.256	0.218
Multiplier	0.135	0.133	0.129	0.123	0.095
	(in percent)				
Inflation Rate	-0.9%	1.1%	2.8%	4.2%	6.2%
Real Interest Rate	0.9%	0.9%	0.9%	0.9%	0.9%
Money Growth Rate	-0.9%	1.1%	2.7%	4.1%	6.0%
Tax Rate [2/]	18.8%	19.0%	19.2%	19.5%	21.1%

1/ Output from production (excluding remittances).
2/ In percent of net income (income less investment, excluding remittances).

Standard Deviation (in percent)					
	Remittances-to-Income Ratio				
Variable	0%	5%	10%	15%	30%
Output [1/]	0.79	0.85	0.91	0.97	1.17
Remittances	-	0.42	0.45	0.49	0.59
Cash Good	1.39	1.45	1.52	1.57	1.66
Credit Good	1.34	1.30	1.27	1.23	1.10
Labor	0.20	0.11	0.08	0.15	0.47
Multiplier	4.93	5.46	6.13	6.78	9.65
Price Level	1.39	1.51	1.74	2.01	2.79
Inflation	1.04	1.06	1.08	1.11	1.22
Interest Rate [2/]	0.06	0.06	0.06	0.06	0.05
Debt	0.07	0.07	0.07	0.07	0.07
Money Growth Rate	0.07	0.18	0.29	0.40	0.68
Tax Rate [3/]	2.64	2.62	2.61	2.51	2.11

1/ Output from production (excluding remittances).
2/ Gross rate.
3/ In percent of net income (income less investment, excluding remittances).

Table 3. Simulated Baseline Economy without Remittances

Variable	Cross-Correlation of Output with: x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)
Output	0.10	0.27	0.47	0.71	1.00	0.71	0.47	0.27	0.10
Remittances	-	-	-	-	-	-	-	-	-
Cash Good	0.09	0.23	0.41	0.63	0.89	0.63	0.42	0.24	0.10
Credit Good	0.09	0.24	0.42	0.64	0.90	0.64	0.42	0.24	0.10
Labor	-0.10	-0.27	-0.47	-0.71	-1.00	-0.71	-0.47	-0.27	-0.10
Multiplier	-0.04	-0.14	-0.25	-0.38	-0.54	-0.38	-0.25	-0.15	-0.07
Gov. Spending	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	-0.01
Price Level	-0.05	-0.20	-0.38	-0.61	-0.88	-0.64	-0.44	-0.27	-0.13
Inflation	-0.15	-0.20	-0.25	-0.30	-0.36	0.32	0.27	0.22	0.18
Real Int. Rate	-0.09	-0.25	-0.44	-0.66	-0.93	-0.66	-0.44	-0.25	-0.10
Debt	0.03	-0.09	-0.23	-0.41	-0.63	-0.88	-0.63	-0.41	-0.24
Money Growth	-0.02	-0.09	-0.16	-0.25	-0.35	-0.25	-0.16	-0.10	-0.05
Tax Rate	-0.02	-0.09	-0.16	-0.25	-0.35	-0.25	-0.16	-0.10	-0.05

Variable	Remaining Cross-Correlations [1/] Remit.	Money Growth	Tax Rate	Mult.	Shocks Tech.	Gov.
Output	-	-0.35	-0.35	-0.54	1.00	0.01
Remittances	-	-	-	-	-	-
Cash Good	-	-0.74	-0.74	-0.86	0.89	-0.45
Credit Good	-	-0.71	-0.72	-0.84	0.90	-0.42
Labor	-	0.33	0.34	0.53	-1.00	-0.02
Multiplier	-	0.96	0.98	1.00	-0.54	0.84
Gov. Spending	-	0.92	0.94	0.84	0.01	1.00
Price Level	-	0.71	0.72	0.84	-0.88	0.43
Inflation	-	0.34	0.34	0.38	-0.36	0.22
Real Int. Rate	-	0.66	0.66	0.79	-0.93	0.35
Debt	-	0.45	0.44	0.53	-0.62	0.24
Money Growth	-	1.00	0.98	0.96	-0.35	0.92
Tax Rate	-	0.98	1.00	0.98	-0.35	0.94

1/ The shocks to technology and government spending are exogenous variables while the money growth rate, tax rate, and multiplier are endogenous variables.

Table 4. Simulated Economy with 5 Percent Remittances to Income

Variable	Cross-Correlation of Output with: x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)
Output	0.10	0.27	0.47	0.71	1.00	0.71	0.47	0.27	0.10
Remittances	-0.10	-0.27	-0.47	-0.71	-1.00	-0.71	-0.47	-0.27	-0.10
Cash Good	0.09	0.23	0.41	0.63	0.88	0.63	0.41	0.24	0.09
Credit Good	0.09	0.24	0.43	0.65	0.91	0.65	0.43	0.24	0.10
Labor	-0.09	-0.24	-0.43	-0.65	-0.92	-0.65	-0.43	-0.24	-0.09
Multiplier	-0.05	-0.14	-0.25	-0.39	-0.54	-0.38	-0.25	-0.15	-0.06
Gov. Spending	0.00	0.00	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
Price Level	0.04	-0.10	-0.29	-0.53	-0.81	-0.63	-0.47	-0.33	-0.21
Inflation	-0.15	-0.21	-0.27	-0.34	-0.41	0.26	0.23	0.20	0.17
Real Int. Rate	-0.09	-0.25	-0.44	-0.67	-0.94	-0.67	-0.44	-0.25	-0.10
Debt	0.02	-0.09	-0.23	-0.41	-0.62	-0.87	-0.62	-0.41	-0.23
Money Growth	-0.05	-0.14	-0.24	-0.37	-0.52	-0.37	-0.24	-0.14	-0.06
Tax Rate	-0.04	-0.10	-0.18	-0.27	-0.38	-0.27	-0.18	-0.10	-0.05

Variable	Remaining Cross-Correlations [1/] Remit.	Money Growth	Tax Rate	Mult.	Shocks Tech.	Gov.
Output	-1.00	-0.52	-0.38	-0.54	1.00	-0.02
Remittances	1.00	0.52	0.38	0.54	-1.00	0.02
Cash Good	-0.88	-0.86	-0.77	-0.87	0.87	-0.49
Credit Good	-0.91	-0.82	-0.72	-0.83	0.90	-0.43
Labor	0.92	0.13	-0.02	0.16	-0.93	-0.38
Multiplier	0.54	0.99	0.98	1.00	-0.52	0.85
Gov. Spending	0.02	0.85	0.93	0.85	0.01	1.00
Price Level	0.81	0.76	0.68	0.77	-0.80	0.42
Inflation	0.41	0.46	0.42	0.46	-0.40	0.30
Real Int. Rate	0.94	0.77	0.66	0.78	-0.93	0.35
Debt	0.62	0.53	0.45	0.51	-0.61	0.25
Money Growth	0.52	1.00	0.97	0.99	-0.49	0.85
Tax Rate	0.38	0.97	1.00	0.98	-0.35	0.93

1/ The shocks to technology and government spending are exogenous variables while the money growth rate, tax rate, and multiplier are endogenous variables.

Table 5. Simulated Economy with 15 Percent Remittances to Income

	Cross-Correlation of Output with:								
Variable	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)
Output	0.20	0.28	0.47	0.71	1.00	0.71	0.47	0.28	0.11
Remittances	-0.05	-0.28	-0.47	-0.71	-1.00	-0.71	-0.47	-0.28	-0.11
Cash Good	0.25	0.25	0.42	0.62	0.87	0.62	0.41	0.24	0.09
Credit Good	0.22	0.26	0.44	0.67	0.93	0.67	0.44	0.26	0.10
Labor	0.09	0.20	0.33	0.50	0.69	0.50	0.33	0.19	0.07
Multiplier	0.62	-0.16	-0.26	-0.39	-0.53	-0.38	-0.25	-0.14	-0.05
Gov. Spending	0.26	-0.03	-0.05	-0.06	-0.08	-0.06	-0.04	-0.02	0.01
Price Level	0.34	0.02	-0.14	-0.36	-0.64	-0.56	-0.47	-0.39	-0.30
Inflation	-0.03	-0.23	-0.30	-0.39	-0.50	0.14	0.15	0.15	0.15
Real Int. Rate	-0.09	-0.27	-0.45	-0.68	-0.96	-0.68	-0.45	-0.26	-0.10
Debt	0.02	-0.10	-0.23	-0.39	-0.59	-0.83	-0.60	-0.40	-0.23
Money Growth	-0.02	-0.17	-0.27	-0.41	-0.57	-0.41	-0.27	-0.15	-0.05
Tax Rate	0.20	-0.13	-0.22	-0.32	-0.45	-0.32	-0.21	-0.12	-0.04

	Remaining Cross-Correlations [1/]					
					Shocks	
Variable	Remit.	Money Growth	Tax Rate	Mult.	Tech.	Gov.
Output	-1.00	-0.57	-0.45	-0.53	1.00	-0.08
Remittances	1.00	0.57	0.45	0.53	-1.00	0.08
Cash Good	-0.87	-0.90	-0.83	-0.87	0.83	-0.56
Credit Good	-0.93	-0.82	-0.74	-0.80	0.90	-0.43
Labor	-0.69	-0.99	-0.95	-0.97	0.64	-0.77
Multiplier	0.53	0.98	0.99	1.00	-0.47	0.88
Gov. Spending	0.08	0.85	0.93	0.88	-0.01	1.00
Price Level	0.64	0.60	0.55	0.59	-0.61	0.35
Inflation	0.50	0.62	0.58	0.60	-0.47	0.44
Real Int. Rate	0.96	0.78	0.68	0.75	-0.93	0.36
Debt	0.59	0.52	0.45	0.46	-0.57	0.26
Money Growth	0.57	1.00	0.98	0.98	-0.51	0.85
Tax Rate	0.45	0.98	1.00	0.99	-0.38	0.93

1/ The shocks to technology and government spending are exogenous variables while the money growth rate, tax rate, and multiplier are endogenous variables.

Table 6. Simulated Economy with 30 Percent Remittances to Income

	Cross-Correlation of Output with:								
Variable	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)
Output	0.11	0.27	0.47	0.71	1.00	0.71	0.47	0.27	0.11
Remittances	-0.11	-0.27	-0.47	-0.71	-1.00	-0.71	-0.47	-0.27	-0.11
Cash Good	0.10	0.23	0.40	0.60	0.84	0.60	0.39	0.22	0.09
Credit Good	0.11	0.26	0.45	0.68	0.96	0.68	0.45	0.26	0.10
Labor	0.11	0.26	0.44	0.67	0.94	0.67	0.44	0.25	0.10
Multiplier	-0.05	-0.12	-0.21	-0.31	-0.43	-0.30	-0.19	-0.10	-0.04
Gov. Spending	-0.01	-0.03	-0.05	-0.07	-0.09	-0.06	-0.03	-0.01	0.00
Price Level	0.19	0.09	-0.04	-0.22	-0.45	-0.43	-0.39	-0.34	-0.30
Inflation	-0.14	-0.21	-0.31	-0.41	-0.53	0.06	0.09	0.11	0.11
Real Int. Rate	-0.11	-0.26	-0.46	-0.70	-0.98	-0.69	-0.46	-0.26	-0.11
Debt	0.02	-0.07	-0.18	-0.33	-0.51	-0.72	-0.51	-0.34	-0.19
Money Growth	-0.06	-0.14	-0.24	-0.36	-0.50	-0.35	-0.22	-0.12	-0.05
Tax Rate	-0.07	-0.16	-0.28	-0.42	-0.58	-0.41	-0.26	-0.14	-0.05

	Remaining Cross-Correlations [1/]					
					Shocks	
Variable	Remit.	Money Growth	Tax Rate	Mult.	Tech.	Gov.
Output	-1.00	-0.50	-0.58	-0.43	0.99	-0.09
Remittances	1.00	0.50	0.58	0.43	-0.99	0.09
Cash Good	-0.84	-0.89	-0.92	-0.83	0.78	-0.61
Credit Good	-0.96	-0.71	-0.78	-0.66	0.93	-0.36
Labor	-0.94	-0.76	-0.82	-0.70	0.90	-0.42
Multiplier	0.43	0.96	0.97	1.00	-0.34	0.92
Gov. Spending	0.09	0.89	0.86	0.92	0.01	1.00
Price Level	0.45	0.41	0.43	0.37	-0.43	0.25
Inflation	0.53	0.75	0.75	0.71	-0.47	0.60
Real Int. Rate	0.98	0.66	0.74	0.60	-0.95	0.29
Debt	0.51	0.40	0.41	0.28	-0.49	0.19
Money Growth	0.50	1.00	0.97	0.96	-0.41	0.89
Tax Rate	0.58	0.97	1.00	0.97	-0.49	0.86

1/ The shocks to technology and government spending are exogenous variables while the money growth rate, tax rate, and multiplier are endogenous variables.

Table 7. Utility Equivalence Over No-Remittance Economy

	Remittances-to-Income		
	5%	15%	30%
	(Per period increase, in percent)		
Total Utility	4.7	12.9	22.8
Consumption	2.6	7.7	14.1
Cash Good	0.6	2.3	5.9
Credit Good	5.1	14.1	23.9
Labor	6.3	16.9	29.4

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