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Remittances and the informal economy☆

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ABSTRACT

Many developing countries are characterized by a large informal sector, and are also often heavily dependent on remittance inflows from abroad. We develop a general equilibrium framework to understand better the dynamic absorption of remittances in a two-sector small open economy, by incorporating many of the stylized features of the informal sector. Calibrating the model to yield a long-run equilibrium consistent with sample averages for 56 developing countries for the period 1990–2014, we show that the effect of remittances depends critically on how they impinge on the recipient economy, i.e., whether these inflows are (i) permanent or temporary, (ii) associated with a collateral effect to securitize borrowing, and (iii) exogenous or countercyclical. We also identify the conditions under which remittances are associated with an expansion of the informal sector, as well as the Dutch Disease effect.

1. Introduction

Most developing countries are characterized by a large informal sector, populated mainly by small, unregistered firms having low productivity, and producing basic non-traded goods and services. As Schneider et al. (2010) and La Porta and Shleifer (2014) document, this sector absorbs a disproportionately large share of the labor force, with limited outward mobility and access to credit. At the same time, many of these countries are also often heavily dependent on large capital inflows such as remittances, sent by migrant workers living and working abroad.[1] Table 1 reports the average share of the informal sector and remittances in GDP for 56 developing countries, for the period 1990–2014. The average share of the informal sector's output in GDP was about 32% during this period, while its employment share was above 50%.[2] During this period these countries received, on average, about 3.3% of their GDP in the form of remittances, with a range varying from 0.04% to 12%.[3] Even though the dynamic absorption of remittances has recently emerged as an important topic of research, very little is known about the impact of these inflows in the presence of a large informal sector.

The central objective of this paper, therefore, is to propose a quantitative general equilibrium framework that analyzes the dynamic effects of remittances not only on the aggregate economy, but also on the

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[1] Over the last two decades, remittances have overtaken foreign aid as the second largest flow of capital across the world, second to only FDI (Yang, 2011).

[2] It is important to clarify here that there are varying definitions of employment in the informal sector. For example, The International Labor Organization makes a distinction between "employment in the informal sector," which is an enterprise-based concept, defined as jobs in unregistered/unincorporated private enterprises, and "informal employment," which is a job-based concept covering *all* employment, both in the formal and informal sector that lack basic social and legal protections; See ILO (2011). For the purpose of this paper, we adopt the enterprise-based measure, i.e., "employment in the informal sector."

[3] The complete list of countries is available in the Appendix.

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Table 1
Remittances and the informal economy, 1990–2014.

	Mean	Median	Min	Max	Standard Deviation
Remittances (% of GDP)	3.28	2.07	0.041	12.20	3.22
Informal sector output (% of GDP)[a]	32.15	34.00	11.00	45.00	7.42
Self-employment (% of total employment)	51.03	46.39	7.75	93.40	22.68
Informal employment (% of total employment)[b]	58.17	58.78	26.5	83.93	15.95

Number of countries = 56.
[a] Informal sector output data is only available for the period 1999–2007.
[b] Informal Employment data is for the latest year available in the sample (ILO, 2011).
Data Source: Schneider et al. (2010), OECD, WDI, ILO.

evolution of its formal and informal sectors. An additional, but important, consideration is whether remittances can help alleviate borrowing constraints faced by developing countries. Specifically, is there a collateral effect associated with remittance inflows that countries might leverage to access international capital markets? Ratha (2007) reports that commercial banks in emerging market countries such as Brazil, Egypt, El Salvador, and Mexico, among others, have been able to raise cheaper and longer-term financing (more than $15 billion since 2000) from international capital markets via the securitization of future remittance inflows. Other authors, including Gupta et al. (2007) and Hughes (2011), also review evidence pointing to the growing importance of remittances acting as a collateral for aggregate debt. Indeed, as Table 2 shows, country-level risk premia on borrowing tend to decline with the share of remittance receipts in GDP. The potential for remittances as collateral in the securitization of debt has not yet been studied systematically in the literature.

A priori, there are several underlying mechanisms that may potentially drive the relationship between remittances, the macroeconomy, and its sectoral composition. First, by augmenting the financial resources of recipient households, remittances may be allocated to either the consumption of formal or informal sector goods (including leisure), or saved. Second, households in developing countries typically face substantial *intersectoral* adjustment costs with respect to both labor and capital mobility, which may affect the sectoral and aggregate absorption of remittances. A related issue here is whether remittances facilitate the accumulation of capital in the informal sector, evidence for which has been found by Woodruff and Zenteno (2007) and Yang (2008). Third, the presence of an informal sector also raises the possibility of the Dutch Disease phenomenon, where an appreciation of the real exchange rate precipitates an aggregate contraction in GDP together with an expansion of the share of informal production. Fourth, whether remittances can serve as a collateral for borrowing may have important consequences for investment, intersectoral factor mobility, and sectoral production. Fifth, the duration of remittance inflows may also matter: recipients may respond very differently to an inflow of remittances that is temporary relative to one that is permanent. Finally, if remittance inflows are countercyclical, they may have potential business cycle smoothing effects.

We develop a two-sector model of an open economy that incorporates many of the stylized features of the informal sector. Specifically, the economy produces two goods: a traded good that can be used for consumption or investment, manufactured in the formal sector, and a non-traded consumption good (such as services) produced in the informal sector. Private capital is traded internationally, and can be used for production in both sectors. However, we assume that the intersectoral transfer of capital is a costly process, i.e., additional resources are used up in moving capital from the formal to the informal sector. Analogously, we assume that the movement of labor across the two sectors also incurs an adjustment cost. These convex adjustment costs reflect the inflexibilities in capital and labor markets characteristic of developing economies, and generate sluggish inter-sectoral mobility for both factors, in line with the findings of La Porta and Shleifer (2014). We also assume that informal work is characterized by self-employment, while firms in the formal sector purchase labor from households at the prevailing market wage rate. Thus, households consume both goods, allocate time to (i) leisure, (ii) self-employment in the informal sector and (iii) salaried employment in the formal sector. They invest in formal sector firms as well as in informal production, and receive a flow of remittances from abroad. For the household, income from the formal sector is subject to taxation by the government, but income derived in the informal sector manages to avoid being taxed. The government collects tax revenues from the formal sector and provides a public consumption good.

Table 2
Country risk premium and remittances, 1990–2014.

Rem/GDP	Risk Premium	Rem/GDP Mean	Rem/GDP Min	Rem/GDP Max
0-1%	10.20	0.50	0.24	0.93
1-3%	6.78	2.07	1.34	2.99
3-6%	6.62	4.76	3.78	5.66
>6%	5.57	9.06	7.06	11.32

Note: Risk premium on lending is the interest rate charged by banks on loans to private sector customers minus the "risk free" Treasury bill interest rate at which short-term government debt is issued.

The model is closed by assuming that both households and the government have access to an internationally traded bond that can be used to accumulate debt over time. The key feature here is that both agents face an endogenous borrowing cost determined by a mark-up over the world interest rate, with the markup itself reflecting the economy's debt-servicing capacity. In defining the economy's debt-servicing capacity, we assume that remittance inflows may be used to securitize debt at the aggregate level, by acting as a collateral. We interpret this collateral effect as a financial policy in our model which, when combined with GDP, augments the economy's aggregate debt-servicing capacity.

The analytical model is calibrated to yield a long-run equilibrium consistent with sample averages for 56 developing countries for the period 1990–2014. Our results indicate that while a permanent increase in remittance inflows leads to a short-run expansion of economic activity, an aggregate contraction characterizes the long run. The adjustment of the real exchange rate plays a crucial role in this context. Essentially, an instantaneous real appreciation of the exchange rate, by raising the relative price of informal production, diverts resources into this sector. As such, both the share of informal output and employment increase over time, together with investment in this sector. Since the formal sector is relatively more productive to begin with, this reallocation of resources toward informal production reduces the economy's aggregate productive capacity, leading to a long-run economic contraction. Consequently, the Dutch Disease phenomenon emerges in the long run: a real exchange rate appreciation, coupled with a contraction of GDP and the share of employment and output of the formal sector. These results also underscore the role of remittances in driving self-employment and investment in the informal sector.

In contrast, if the remittance inflow is associated with a collateral effect, the real exchange rate depreciates, as the economy's borrowing and debt-servicing capacity increases. This releases resources for investment goods (produced in the formal sector) and, consequently, increases the demand for labor in the formal sector. As a result, the share of the informal economy declines over time, enabling resources to move to the more productive formal sector. The long run is therefore characterized by an aggregate expansion of economic activity. Overall, we show that a strong collateral effect can more than offset the forces that lead to the Dutch Disease associated with a remittance shock. The Dutch Disease phenomenon in our model also depends on the duration of the remittance shock. A temporary shock to remittance inflows causes a real depreciation of the exchange rate and a short-run contraction, both in GDP as well as informal production, before the economy adjusts back to its pre-shock equilibrium. Again, the presence of a collateral effect can help the formal sector and the aggregate economy expand in the short run, as the

economy adjusts to the temporary increase in remittances. This is an interesting result from a policy perspective, in that it suggests that one way to reduce the relative size of the informal sector – thereby preventing the Dutch Disease-type phenomenon associated with an increase in remittances – might be to introduce a collateral policy that enables some portion of remittances to securitize debt.

In the case where remittance inflows are not exogenous but countercyclical (driven by a negative productivity shock in the recipient economy), we find that these inflows can have a (small) business cycle smoothing effect by partially muting the resulting contraction of the aggregate economy. Also, we demonstrate the countercyclical nature of (self) employment in the informal sector, consistent with recent empirical evidence (see discussion in Section 2). In fact, when remittances are countercyclical, the safety-net feature of self-employment in the informal sector is magnified.

The rest of the paper is organized as follows. Section 2 provides a summary of the current literature on remittances and informality. Section 3 outlines the theoretical model, Section 4 describes the macroeconomic equilibrium and fiscal sustainability, and Section 5 discusses the calibration of the benchmark equilibrium. Section 6 considers permanent remittance shocks and the collateral effect, along with a sensitivity analysis, while Section 7 examines temporary shocks, including the case of countercyclical remittances. Finally, Section 8 concludes.

2. Literature on remittances and informality

In this paper, we address an important and seemingly neglected aspect of economic development. To our knowledge, research on the informal economy, and that on remittances, have evolved independently of each other. For example, studies on the informal economy have generally focused either on (i) the measurement of its relative size (Schneider and Enste, 2000; La Porta and Shleifer, 2008, 2014, and Gomis-Porqueras et al., 2014), (ii) issues pertaining to tax policy and enforcement (Rauch, 1991; Ihrig and Moe, 2004; Turnovsky and Basher, 2009; Prado, 2011; Ordonez, 2014), or (iii) its behavior over the business cycle and labor market characteristics (Amaral and Quintin, 2006; Mandelman and Montes-Rojas, 2006; Fiess et al., 2010; Loayza and Rigolini, 2011; Finkelstein Shapiro, 2014; Fernandez and Meza, 2015). On the other hand, the literature on remittances has focused mainly on economic growth and the macroeconomic adjustment of what can be characterized as formally structured economies; see, for example, Yang (2008), Giuliano and Ruiz-Arranz (2009), Acosta et al. (2009), Durdu and Sayan (2010), Mandelman and Zlate (2012), and Mandelman (2013). In either case, there has been no systematic analysis linking the role of remittances and the evolution of the informal economy, despite their relative size and potential linkages.

The main results of our analysis, as summarized in Section 1, also provide a step towards reconciling the ambiguity in the literature with respect to the aggregate and sectoral effects of remittances. For example, several authors such as Durand et al. (1996), Brown and Ahlburg (1999), Combes and Ebeke (2011) have documented that remittances finance mainly household consumption. On the other hand, Woodruff and Zenteno (2007), Yang (2008), and Alcaraz et al. (2012) find that remittances are associated with increased investment.[4] Our results indicate that both sets of findings in the literature can be reconciled if one carefully characterizes the underlying nature of remittance inflows; i.e., exogenous versus countercyclical, permanent versus temporary, and whether they are associated with a collateral effect. Further, our results are also consistent with recent empirical evidence that points to (i) the countercyclical nature of self-employment in the informal sector (Bosch and Maloney, 2008; Loayza and Rigolini, 2011; Finkelstein Shapiro, 2014; Fernandez and Meza, 2015), and (ii) the relationship between remittance flows and the Dutch Disease phenomenon (Acosta et al., 2009; Amuendo-Dorantes and Pozo, 2004).

It is important to evaluate our results relative to two papers to which our work is closely related. First, Durdu and Sayan (2010) build a two-sector endowment economy with traded and non-traded goods to examine the business-cycle smoothing effects of remittances in the presence of financial frictions. We distinguish our approach from theirs by embedding a richer sectoral production structure, a collateral effect associated with remittances, structural features characteristic of the informal sector such as the costly intersectoral movement of factors of production and the countercyclicality of self-employment, while examining a broader set of questions pertaining to remittance inflows. Second, Finkelstein Shapiro and Mandelman (2016) employ a two-sector model to study the effects of remittances on self-employment in Mexico. We focus on three aspects absent from their analysis, namely (i) how the duration of remittance flows (permanent versus temporary) differentially affect aggregate and sectoral outcomes, (ii) the role of the collateral effect, and (iii) the role of real exchange rate dynamics in determining the absorption of remittance flows.[5]

3. Analytical framework

We begin by outlining the analytical framework. The description below is general, with the specific functional forms employed in the simulations listed in Table 3.

3.1. Households and informal self employment

The economy is populated by an infinitely-lived representative household that maximizes utility:

$$\int_0^\infty \left[U\left(C_f, C_s\right) + \Phi(l)\right] e^{-\beta t} dt \tag{1}$$

where, C_f and C_s represent the private consumption of goods produced in the formal and informal sectors, respectively, l represents time allocated to leisure, and β is the rate of time preference. The function $U(.)$ has the standard curvature properties, i.e., both consumption goods yield positive but diminishing marginal utility. For simplicity, we assume that the utility derived from leisure is additively separable. The household allocates the rest of its time endowment to working for firms in the formal sector and self-employment in the informal sector, and earns a return on private capital rented out to formal sector firms. Production in the economy takes place in two sectors: a formal sector (denoted by the subscript *f*), which produces a traded good that can be used either for consumption or investment, and via self-employment in an informal sector (denoted by the subscript *s*), which produces a basic non-traded consumption good (e.g., services).[6]

Households also accumulate debt (through an internationally traded bond) to finance any excess expenditure over earnings:

$$\begin{aligned}\dot{N} = {} & rN + C_f + I_f + \Omega_f\left(I_f, K_f\right) - (1-\tau)\left[r_f K_f + w_f L_f\right] \\ & -p[Y_s(K_s, L_s) - C_s - \Omega_s(X, K_s)] + T_f - R\end{aligned} \tag{2}$$

[4] In addition, while Chami et al. (2005) and Barajas et al. (2009) find that the relationship between remittances and economic growth is either neutral or negative, Mundaca (2009) finds remittances to be beneficial for long-run growth. Giuliano and Ruiz-Arranz (2009) and Bettin and Zazzaro (2012) find beneficial effects of remittances on aggregate economic performance conditional on the degree of financial development in the recipient country. These contrasting results can also be reconciled by focusing more precisely on the nature of the remittances.

[5] Finkelstein Shapiro and Mandelman (2016) focus on self-employment and do not incorporate issues specifically related to the informal economy, though evidence strongly suggests that the two are closely related.

[6] The general two-sector production structure is similar to those of previous studies, such as Ihrig and Moe (2004) and Turnovsky and Basher (2009). However, in contrast to our approach, those papers focused on a closed economy and abstract from issues related to the absorption of external transfers such as remittance inflows. In our context of an open economy, the two sectors produce distinct goods (traded and non-traded), generating an endogenously determined real exchange rate, thereby raising issues associated with a small "dependent" economy.

where N is the current stock of household debt, r is the borrowing interest rate, I_f is the household's investment in the formal sector, $\Omega_f(.)$ incorporates a convex adjustment cost associated with accumulating private capital in the formal sector (and is homogeneous of degree one), τ is the tax rate on income earned in the formal sector, while r_f and w_f represent the household's return on capital K_f and labor L_f respectively, in the formal sector. Output from informal self-employment is denoted by Y_s, $\Omega_s(.)$ is the cost of installing capital in the informal sector, and p is the relative price of the informal sector good. Finally, T_f denotes a lump-sum tax, and R represents an inflow of remittances received by the household from abroad.[7] Both sectoral production functions have the usual neoclassical properties. Also, while household income earned in the formal sector is subject to taxation by the government, income derived from the informal sector escapes taxation. Further, since the formal sector produces the economy's traded good (taken as numeraire) and the informal sector produces the non-traded good, the relative price of the informal sector good, p, mirrors the economy's real exchange rate.[8] As such, an increase (decrease) in p denotes a real appreciation (depreciation) of the exchange rate.

Households invest in formal sector firms, with its ownership of capital stock in that sector evolving according to

$$\dot{K}_f = I_f - X - \Gamma(X) - \delta K_f \tag{3}$$

Since investment in this economy comes only from formal production, a key feature of the accumulation equation (3) is that the household needs to transfer an amount X to the informal sector to accumulate capital in that sector. We assume that this transfer of investment is subject to a convex intersectoral mobility cost, specified by $\Gamma(X)$.[9] In the informal sector, therefore, capital accumulates according to

$$\dot{K}_s = X - \delta K_s \tag{4}$$

where K_s is the stock of capital in the informal sector, and δ is the (common) depreciation rate of capital in both sectors. The aggregate stock of capital in the economy is thus $K = K_f + K_s$, with its accumulation given by

$$\dot{K} = I_f - \Gamma(X) - \delta K \tag{5}$$

Informal (non-traded) output is solely used for consumption and the installation of capital in that sector, so that

$$Y_s(K_s, L_s) = C_s + \Omega_s(X, K_s), \text{ for all } t \tag{6}$$

3.2. Formal sector production

A representative firm in the formal sector maximizes its flow of profits per period according to

$$Y_f\left(K_f, L_f\right) - r_f K_f - w_f L_f \tag{7}$$

where, $Y_f(K_f, L_f)$ represents the flow of output from formal production. The formal sector is assumed to include well-defined factor markets, so that profit maximization yields the usual first-order conditions

$$r_f = \frac{\partial Y_f}{\partial K_f} \equiv r_f\left(K_f, L_f\right);\ w_f = \frac{\partial Y_f}{\partial L_f} \equiv w_f\left(K_f, L_f\right) \tag{8}$$

3.3. Labor market

An important feature of the economy is the presence of labor market rigidity, which reflects the structural inefficiencies characteristic of developing economies. These inefficiencies reflect factors such as the absence of formal institutions to promote coordination between employer and employee, the reliance on social networks involving friends and relatives, and ethnic and religious associations to facilitate the job search.[10] Households are endowed with one unit of time that can be used for working in the formal sector (L_f), the informal sector (L_s), or consuming leisure, l . Therefore, $1 - l$ measures the labor force participation rate in this economy and implies the following time allocation[11]

$$L_f + L_s + l = 1 \tag{9}$$

Suppose an agent seeks to increase his employment in the formal sector, by reducing his employment in the informal sector at the rate u. In the process of this reallocation, we assume $(\chi/2)u^2$ amount of labor time is temporarily lost in moving employment across sectors. The parameter χ determines the rate of this loss and reflects the underlying rigidity in the labor market.[12] Thus, the exodus out of the informal sector and the evolution of employment in the formal sector are given by

$$\dot{L}_s = -u \tag{10a}$$

$$\dot{L}_f = u - \frac{\chi}{2}u^2 - zL_f + \sigma l \tag{10b}$$

where the parameters σ and z represent the rate at which time is allocated out of, and into, the consumption of leisure, respectively. Taking the time derivative of (9) and combining with (10a) and (10b) yields the rate at which leisure is evolving

$$\dot{l} = \frac{\chi}{2}u^2 + zL_f - \sigma l \tag{11}$$

The presence of labor mobility costs, as described in (10b), generates sluggishness in the adjustment of sectoral labor supply, which implies that the sectoral labor allocation decisions L_f and L_s, represent *investment* decisions, analogous to those involving asset accumulation. Our specification of labor movements as a gradual process contrasts with that of some earlier contributions (e.g. Ihrig and Moe, 2004; García-Peñalosa and Turnovsky, 2005) who allow labor to move instantaneously, but is a more accurate description of the process in developing countries.[13]

[7] In our baseline specification, we assume that remittance inflows are exogenous in nature. However, in Section 6 we also consider the case of endogenous (countercyclical) remittances that can respond to fluctuations in aggregate output.

[8] See, for example, Betts and Kehoe (2008), who provide evidence of a strong positive correlation between the relative price of non-traded goods and the real exchange rate.

[9] Intersectoral mobility costs for capital have been studied extensively in the context of the two-sector Heckscher-Ohlin model in international trade; see Mayer (1974), Jones (1975), and Neary (1982). More recently, these costs have been incorporated within the framework of small open economy macro models, as in Morshed and Turnovsky (2004), van der Ploeg (2011), and Chatterjee and Mursagulov (2016).

[10] For example, more than 72 percent of those who work in the shadow economy and more than 52 percent of those who work in the formal sector rely on the social networks to move from one sector to another in Venezuela (Marquez and Ruiz-Tagle, 2004). These networks pay off only when someone is already unemployed for a while (Marquez and Ruiz-Tagle, 2004; Gong et al., 2004; Serneels, 2007).

[11] This is a slightly loose definition for the labor force participation rate, since the model does not generate any involuntary unemployment. For example, if there were job seeking and separation every period, then these allocations of time would also be included in the labor force participation rate. In our specification, the agent either works or consumes leisure, which implies that the fraction of time allocated to working in the two sectors is identical to the labor force participation rate.

[12] We take the rigidity parameter, χ, to be given. However, one could argue that one of the benefits of remittances is to reduce the labor market rigidity and facilitate migration to the formal sector.

[13] The instantaneous movement between sectoral labor and leisure is obtained by setting $\chi = z = 0$, and $\sigma \to \infty$. An alternative approach to modeling intersectoral movements of labor would be to incorporate unemployment and build on the more recent search and matching literature as applied to developing countries. Though our approach to the labor market is somewhat more reduced-form, the main results remain unaffected by these modeling choices. Moreover, our principal focus is not the structure of the labor market per se, but rather the dynamic absorption of remittances in the presence of an informal sector.

3.4. The government and current account

The government accumulates debt to finance excess public expenditures net of revenues

$$\dot{B} = rB + G_C - \tau\left(r_K K + w_f L_f\right) - T_f \tag{12}$$

where B is the current stock of government (public) debt and G_C is government consumption.[14] The evolution of the economy's current account is obtained by combining the household and government budget constraints

$$\dot{V} = r()V + C_f + I_f + \Omega_f() + G_C - Y_f - R \tag{13}$$

where, $V \equiv N + B$ denotes the aggregate stock of debt of the economy, comprising the sum of private (household) debt, N, and public (government) debt, B. In deriving (13), the informal sector market clearing condition (6) has been imposed.

We assume that the borrowing rate on debt is a mark-up over the world interest rate, r^*, with the borrowing premium, $\omega(.)$, increasing with the economy's aggregate stock of debt relative to its debt-servicing capacity:

$$r = r^* + \omega\left(\frac{V}{Y + \kappa R}\right), \quad \omega' > 0,\ \kappa \in [0, 1] \tag{14}$$

We assume that the economy's capacity to service its outstanding debt is determined by two factors: (i) its aggregate GDP, $Y \equiv Y_f + pY_s$, measured in units of traded output, and (ii) its inflow of remittances, R, which may serve as a collateral for borrowing purposes. This collateral effect is captured by the parameter κ, which we take to lie in the range (0, 1). Thus, if $\kappa = 0$, remittances cannot serve as collateral for borrowing, while if $\kappa = 1$ remittances can be fully applied as collateral. Thus, $\kappa > 0$ lowers the borrowing premium by enhancing the economy's debt-servicing capacity and, as such, reduces the present value of the economy's outstanding debt. The collateral parameter κ can be viewed as a policy variable, reflecting institutional aspects of credit markets or central bank policy.[15] Being atomistic, in the international financial market, households treat the borrowing rate in (14) as given, although the equilibrium private borrowing rate is determined endogenously as a consequence of the collective private and public borrowing decisions.[16]

4. Macroeconomic equilibrium

The household maximizes (1), subject to (2), (3), (4), (9), (10a) and (10b), given the factor returns in the formal sector, (8). Note that, in making its allocation decisions, the household takes the borrowing rate specified in (14) and government policy as given. The resulting optimality conditions are

$$\frac{\partial U\left(C_f, C_s\right)}{\partial C_f} = q_1 \tag{15a}$$

$$\frac{\partial U\left(C_f, C_s\right)}{\partial C_s} = pq_1 \tag{15b}$$

$$I_f = \psi\left(q_{kf}\right)K_f \tag{15c}$$

$$X = X\left(p, q_{kf}, q_{ks}, K_s\right) \tag{15d}$$

$$u = u\left(q_{lf}, q_{ls}\right) \equiv \frac{1}{\chi}\left(\frac{q_{lf} - q_{ls}}{q_{lf}}\right) \tag{15e}$$

$$\beta - \frac{\dot{q}_1}{q_1} = r \tag{15f}$$

$$\frac{1}{q_{kf}}\left((1-\tau)r_f - \frac{\partial \Omega_f}{\partial K_f}\right) + \frac{\dot{q}_{kf}}{q_{kf}} - \delta = r \tag{15g}$$

$$\frac{p}{q_{ks}}\left(\frac{\partial Y_s}{\partial K_s} - \frac{\partial \Omega_s}{\partial K_s}\right) + \frac{\dot{q}_{ks}}{q_{ks}} - \delta = r \tag{15h}$$

$$\frac{1}{q_{lf}}\left\{(1-\tau)w_f - \frac{\Phi_l\left(1 - L_f - L_s\right)}{q_1}\right\} + \frac{\dot{q}_{lf}}{q_{lf}} - (\sigma + z) = r \tag{15i}$$

$$\frac{1}{q_{ls}}\left\{p\frac{\partial Y_s}{\partial L_s} - \frac{\Phi_l\left(1 - L_f - L_s\right)}{q_1}\right\} + \frac{\dot{q}_{ls}}{q_{ls}} - \sigma\left(\frac{q_{lf}}{q_{ls}}\right) = r \tag{15j}$$

where, q_1 is the shadow value of household debt (traded bonds) and q_{kf}, q_{ks}, q_{lf}, and q_{ls} denote the shadow values of private capital in the formal and informal sectors, employment in the formal and informal sectors, respectively, with the latter four shadow values being normalized by q_1.[17] In addition, the following transversality conditions apply:

$$\lim_{t\to\infty} q_1 N e^{-\beta t} = \lim_{t\to\infty} q_{kf} q_1 K_f e^{-\beta t} = \lim_{t\to\infty} q_{ks} q_1 K_s e^{-\beta t} = \lim_{t\to\infty} q_{lf} q_1 L_f e^{-\beta t} = \lim_{t\to\infty} q_{ls} q_1 L_s e^{-\beta t} = 0 \tag{15k}$$

Eqs. (15a) and (15b) equate the marginal utility of consumption for the two consumption goods to the shadow price of household debt, while Eq. (15c) equates the marginal cost of private investment to the shadow price of capital. Eq. (15d) indicates that the investment in capital in the informal sector is a function of the sectoral shadow prices of capital, the real exchange rate, and the existing capital stock in the informal sector. Eq. (15e) describes the rate at which labor moves from one sector to the other. This rate is determined by the difference in the shadow values in the two sectors, and varies inversely with the rigidity in the labor market, as parameterized by χ.[18] Observe that $u \gtrless 0$, implying that agents may also move from the formal to the informal sector, depending upon the relative shadow values. The remaining four conditions, (15f)-(15j) are intertemporal efficiency conditions, equating the return on consumption, the return on sectoral capital, and the net returns on sectoral employment investment, respectively, to the marginal cost of borrowing.

4.1. Equilibrium dynamics

The internal equilibrium dynamics for the economy can be expressed in terms of the evolution of the following quantities: (i) sectoral private capital, (ii) sectoral employment, (iii) national debt, and (iv) the shadow values of debt, private capital, and the sectoral employments.

[14] The reason for introducing public consumption is to facilitate the matching of the calibration to the empirical data. It does not play any meaningful role in the results derived from the model.

[15] The aggregate collateral effect on borrowing can arise from other sources as well. For example, commodity exports can also play a similar role in limiting the country-level risk premium on borrowing; see, for example, Shousha (2016).

[16] A basic issue in modeling small open economies such as this is the closure of the financial market; see Turnovsky (1997) and Schmitt-Grohé and Uribe (2003) where several alternatives are detailed. These include introducing an endogenous borrowing premium, as in (6), which is most appropriate in the case of the developing economy being analyzed here. This approach originated with Bardhan (1967), and many variants can be identified in the literature.

[17] That is, if we let μ_{kf} denote the shadow (utility) value of capital, then $q_{kf} \equiv \mu_{kf}/q_1$, and similarly for the other shadow prices. Written in this way, the normalized prices become "asset prices" independent of utility units, with the optimality conditions (15i) and (15j) treating labor as an asset, analogous to capital.

[18] The parallels between (15d) and the corresponding relation in the pioneering Harris and Todaro (1970) migration model are apparent. That paper postulated the movement of labor between rural and urban areas to be proportional to the current wage differential between the two sectors. In contrast, we find that labor movement is proportional to the differential asset price, which upon integrating the arbitrage relationships (15i) and (15j) forward, is the discounted sum of expected future sectoral after-tax wage differentials.

To derive the equilibrium dynamics, we first solve the static first-order conditions, (15a) and (15b), for the equilibrium sectoral consumption quantities

$$C_j = C_j(p, q_1), \quad j = f, s \tag{16}$$

Using (16) in conjunction with the market-clearing condition for the informal sector,

$$Y_s(K_s, L_s) = C_s(p, q_1) + \Omega_s\left(p, q_{kf}, q_{ks}, K_s\right) \tag{17a}$$

we can derive the short-run equilibrium real exchange rate:

$$p = p\left(q_1, q_{ks}, q_{kf}, K_s, L_S\right) \tag{17b}$$

Also, from (9), we obtain the reduced-form expression for the borrowing rate, $r = r(L_f, L_s, K_f, K_s, q_1, q_{kf}, q_{ks}, V, \kappa R)$.

Using these relationships we can express the macroeconomic equilibrium as

$$\dot{K}_f = \left[\psi\left(q_{kf}\right) - \delta\right]K_f - X\left(p, q_{kf}, q_{ks}, K_s\right) - \Gamma\left(p, q_{kf}, q_{ks}, K_s\right) \tag{18a}$$

$$\dot{K}_s = X\left(p, q_{kf}, q_{ks}, K_s\right) - \delta K_s \tag{18b}$$

$$\dot{L}_s = \frac{1}{\chi}\left(\frac{q_{lf} - q_{ls}}{q_{lf}}\right) \tag{18c}$$

$$\dot{L}_f = \frac{1}{\chi}\left(\frac{q_{lf} - q_{ls}}{q_{lf}}\right) - \frac{\chi}{2}\left(\frac{q_{lf} - q_{ls}}{\chi q_{lf}}\right)^2 - zL_f + \sigma\left(1 - L_f - L_s\right) \tag{18d}$$

$$\dot{V} = r()V + C_f(q_1, p) + \left[\psi\left(q_{kf}\right) + \Omega_f\left(\psi\left(q_{kf}\right)\right)\right]K_f + G_C - Y_f\left(K_f, L_f\right) - R \tag{18e}$$

$$\dot{q}_1 = (\beta - r)q_1 \tag{18f}$$

$$\dot{q}_{kf} = (r + \delta)q_{kf} - (1 - \tau)r_f + \frac{\partial \Omega_f}{\partial K_f} \tag{18g}$$

$$\dot{q}_{ks} = (r + \delta)q_{ks} - p\left(\frac{\partial Y_s}{\partial K_s} - \frac{\partial \Omega_s}{\partial K_s}\right) \tag{18h}$$

$$\dot{q}_{lf} = (r + \sigma + z)q_{lf} + \frac{\Phi_l\left(1 - L_f - L_s\right)}{q_1} - (1 - \tau)w_f \tag{18i}$$

$$\dot{q}_{ls} = rq_{ls} + \sigma q_{lf} + \frac{\Phi_l\left(1 - L_f - L_s\right)}{q_1} - p\frac{\partial Y_s}{\partial L_s} \tag{18j}$$

Taken together, (18a)-(18j) yield an autonomous macro-dynamic equilibrium. The steady-state is characterized by setting $\dot{K}_f = \dot{K}_s = \dot{L}_f = \dot{L}_s = \dot{V} = \dot{q}_1 = \dot{q}_{kf} = \dot{q}_{ks} = \dot{q}_{lf} = \dot{q}_{ls} = 0$ and, along with the market-clearing condition for the informal sector (17a), can be solved for the stationary quantities $\tilde{K}_f, \tilde{K}_s, \tilde{L}_f, \tilde{L}_s, \tilde{V}, \tilde{q}_1, \tilde{q}_{kf}, \tilde{q}_{ks}, \tilde{q}_{lf}, \tilde{q}_{ls}$, and $\tilde{p}$. The government's budget constraint in steady state is

$$\tilde{r}\tilde{B} + G_C = \tau Y_f\left(\tilde{K}_f, \tilde{L}_f\right) + T_f \tag{19}$$

Given the government's policy choices G_C, τ, and T_f, and the steady-state solution from (18), the budget constraint (19) can be solved for the steady-state level of public debt, $\tilde{B}$.[19]

Table 3
Functional forms.

Description	Functional Form
Utility function	$\frac{(C_f^{\theta} C_s^{1-\theta})^{\gamma}}{\gamma} + \varsigma \frac{l^{1+1/\lambda}}{1+1/\lambda}$
Production function-Formal sector	$Y_f = A_f K_f^{\alpha} L_f^{1-\alpha}$
Production function-Informal Sector	$Y_S = A_S K_s^{1-\eta} L_S^{\eta}$
Borrowing cost function	$r = r^* + e^{\frac{\bar{m}(N+B)}{Y+\kappa R}} - 1$
Adjustment cost for investment-Formal Sector	$\Omega_f = \frac{h_f}{2}\left(\frac{I_f^2}{K_f}\right)$
Adjustment cost for investment-Informal Sector	$\Omega_s = \frac{h_s}{2}\left(\frac{X^2}{K_s}\right)$
Intersectoral mobility cost-Capital	$\Gamma = \frac{h}{2}X^2$

5. Calibration and numerical analysis

The macroeconomic equilibrium set out in Sections 4.1 and 4.2 is described by a dynamic system comprising five state variables (K_f, K_s, L_f, L_s, and V), and five co-state variables $(q_1, q_{kf}, q_{ks}, q_{lf}, q_{ls})$. The high dimensionality of this dynamic system and its structural complexity renders an analytical solution intractable. We therefore proceed to analyze the model's local dynamic properties using a numerical calibration, by linearizing the equilibrium dynamics around the steady-state equilibrium described in Section 4.1. Table 3 specifies the functional forms used for calibrating the model, and Table 4 describes the parameterization of the benchmark specification. Our numerical simulations confirm the existence of a saddle-point equilibrium, characterized by five stable (negative) and five unstable (positive) eigenvalues, ensuring a unique stable transitional path.

The intertemporal elasticity of substitution for consumption in utility is given by $1/(1-\gamma)$. We set $\gamma = -1.5$, implying an elasticity of 0.4, well within the range of evidence provided by Guvenen (2006). The rate of time preference, β, is set at 0.06, slightly higher than the typical value of 0.04 used in the macro-growth literature, mainly to capture two features characteristic of a developing economy: relative impatience and higher mortality rates, both of which tend to raise the rate of time preference. The parameter θ reflects the relative weight of the formal consumption good in the utility function, and is calibrated to match the share of informal production in total consumption in our sample (to be described below). The world interest rate, r^* and the borrowing premium are set to yield an aggregate debt-output ratio that is consistent with our reference sample. Further, $\beta > r^*$ ensures that the economy is a net debtor in equilibrium, consequently running a current account deficit.

The sectoral production functions are assumed to be Cobb-Douglas. Several studies have documented that informal sector firms are characterized by extremely low capital-labor ratios; see, for example, Thomas (1992), de Paula and Scheinkman (2007), Di Giannatale et al. (2011), La Porta and Shleifer (2014), and Ordonez (2014). We therefore set α, the share of capital in the formal sector, to be higher than its corresponding share $(1-\eta)$ in the informal sector. To do so, we set α to its standard value of 0.4, and choose the output elasticity of labor in the informal sector, η, to be 0.75, consistent with Turnovsky and Basher (2009). This implies that the output elasticity of capital in the informal sector is 0.25. As we will show below, these choices yield sectoral employment shares that are consistent with those observed in our reference sample.

Information on the collateral effect is sparse. In the benchmark model we set $\kappa = 0$, so that there is no collateral effect associated with remittances. Using evidence provided by Ketkar and Ratha (2009) we also consider the case where $\kappa = 0.13$, as well as increasing κ to 0.25, to illustrate the potential for the collateral effect to eliminate the Dutch

[19] Writing the household budget constraint (4) as $\dot{N}(t) = r(t)N(t) + X(t) + T_f(t)$, the first transversality condition in (13) can be written as $N_0 + e^{\int_0^t r(\tau)d\tau}\int_0^t [X(\tau) + T_f(\tau)]e^{-\int_0^\tau r(s)ds}d\tau = 0$, which constrains the path for lump sum taxes.

Table 4
Parameterization of the benchmark model.

Parameter	Description	Value
$1/(1-\gamma)$	Intertemporal elasticity of substitution in consumption	0.4
β	Rate of time preference	0.06
θ	Relative weight of formal-sector good in utility	0.46
λ	Elasticity of leisure in utility	0.22
$\overline{\omega}$	Borrowing premium-Households	0.025
r^*	World interest rate	0.04
κ	Collateral parameter	0
φ	Remittance sensitivity to GDP (countercyclical case)	−2
A_f	Productivity level-formal sector	1
A_s	Productivity level-informal sector	0.75
α	Share of private capital in formal sector	0.4
h_f	Adjustment cost for investment-formal sector	0.85
h_s	Adjustment cost for investment-informal sector	0.85
δ	Depreciation rate for private capital (annual)	0.07
η	Share of labor in informal sector production	0.75
z	Rate of exit to leisure	0.06
σ	Rate of entry from leisure	0.05
χ	Labor mobility cost	15
$\boldsymbol{h}$	Investment mobility cost	15
τ	Tax rate on formal sector output	0.1

Disease effect associated with pure remittances.[20] These two scenarios reflect a somewhat "weak" collateral effect, with 13 percent of remittance inflows being used as a collateral for securing debt, and stronger effect where 25 percent of remittances can be used as collateral.[21]

Based on empirical estimates provided by Finkelstein Shapiro and Mandelman (2016), the adjustment cost parameters for sectoral investment are set to $h_f = h_s = 0.85$. The intersectoral labor and investment mobility costs draw upon evidence provided by Morshed and Turnovsky (2004) and Turnovsky and Basher (2009) and are set at $\chi = h = 15$.[22] The depreciation rate for private capital is set at 7% per year, consistent with empirical evidence for developing countries provided by Schündeln (2013). The values for the entry and exit rates to and from the labor force are chosen to yield an equilibrium labor force participation rate that is consistent with our reference data (to be described below in Section 5.1). The income tax rate on formal sector output is backed out from the sample means of (i) share of tax revenues in GDP, and (ii) the share of the informal sector in GDP. The sectoral productivity parameters A_f, A_s are set such that $A_f > A_s$, and the model is evaluated at an annual frequency.[23]

5.1. Benchmark equilibrium

The benchmark steady-state equilibrium quantities are reported in Table 5. We compare these quantities to their corresponding annual estimates from a sample of 56 countries for the period 1990–2014.[24] Given the poor coverage for informal employment in the data, we use the share of self-employment in the non-agricultural labor force as a proxy. The shares of private and public consumption, public and private debt, remittances, and tax revenues in GDP are obtained from the WDI. Finally, we use the calculations in Schneider et al. (2010) to get the average output share of the informal sector in GDP.

Table 5
Benchmark steady-state equilibrium.

Variables	Description	Model	Data[a]	Data Source
C/Y	Consumption-output ratio (%)	69.56	68.47	WDI
K/Y	Capital-output ratio	2.01	3.03	WDI
B/Y	Public debt-output ratio (%)	48.83	48.04	WDI
N/Y	Private debt-output ratio (%)	30.38	30.89	WDI
Y_s/Y	Share of informal sector in GDP (%)	37.67	32.15	Schneider et al. (2010)
L_s/L	Share of informal employment (%)	55.71	51.03	WDI
1-l	Labor force participation rate (%)	67.24	64.57	WDI
Calibrated Variables				
G_C/Y	Government consumption (share of GDP, %)	13.67	13.67	WDI
R/Y	Remittances (share of GDP, %)	3.28	3.28	WDI

[a] Sample averages for 56 developing countries for the period 1990–2014. Informal sector output data is only available for the period 1999–2007. Informal employment is proxied by the share of self-employment in the non-agricultural labor force.

From Table 5, we see that the benchmark equilibrium implied by our model specification matches closely the corresponding sample averages. The share of consumption in GDP and the private capital-output ratio are about 70% and 2.01, respectively. The share of public debt in GDP is about 49%, while that of private debt is 30%. The informal sector accounts for about 38% of GDP, while employing 56% of the labor force. Finally, the household allocates about 67% of its time endowment to work in both the sectors, consuming the rest as leisure. All of these equilibrium quantities are close to their corresponding empirical estimates, indicating that our benchmark economy is a good representation of a developing country with a sizable informal sector. The policy and transfer variables in the model are parameterized to match their corresponding averages in the data. Consequently, the share of remittances in GDP is set at 3.28%, to match its corresponding sample average. Similarly, the share of government consumption is set to its sample average of 13.67% of GDP.

6. Permanent shocks

In this section, we analyze the dynamic consequences of three types of permanent shocks: (i) a one percent increase in the level of remittances, R, relative to its benchmark, (ii) the introduction of a pure collateral effect through a change in financial policy, where κ in (14) increases from 0 to 0.13, with R remaining unchanged, and (iii) a one percent increase in remittance inflows that is accompanied by the introduction of a collateral effect. In this latter case two alternatives are considered, namely the baseline change, where κ increases from 0 to 0.13 (see footnote 21) and a stronger effect where κ is raised further to 0.25. The numbers reported in Table 6 and the plotted transition paths illustrated in Figs. 1–3 represent percentage deviations from the pre-shock steady-state equilibrium.

6.1. Increase in remittances

Comparing the first row of Table 6 and the dynamic time paths in Fig. 1, we see that the long-run aggregate effects of a pure remittance shock are generally *contractionary*, but with sharp intertemporal trade-offs. As Table 6 indicates, both GDP and the aggregate capital stock decline in the steady state, together with a contraction (expansion) of the economy's output and employment shares in the formal (informal) sector. In contrast, both aggregate consumption and welfare increase. There is a long-run real appreciation of the exchange rate, with an improvement in the economy's net debt position.

An interesting aspect to note here is the presence of a long-run *Dutch Disease* effect: a remittance inflow leads to a long-run a real appreciation of the exchange rate, a contraction of the shares of output and

[20] Ketkar and Ratha (2009, Table 2.6) suggest that in 2007 remittance flows had the potential of raising new debt equal to about 10% of the value of the remittance inflows, without raising borrowing costs. In terms of our specification of borrowing costs in (14), we interpret this as asserting that $V_1/(Y+\kappa R) = V_0/Y$ where $V_1 - V_0 = 0.10R$. This implies $\kappa = 0.10Y/V_0$ which at the base steady-state summarized in Table 5 suggests $\kappa \approx 0.13$.

[21] Another way to think of the magnitude of the collateral parameter κ is in the context of an economy that receives some of its remittance inflows via informal channels that are outside the radar of the formal banking sector. Therefore, low values of κ may reflect that a large proportion of remittance inflows come in to the country through informal channels and therefore cannot be used as collateral by the organized banking sector. A high value of κ then reflects that a large share of remittances come in through the formal banking system; See, for example, Freund and Spatafora (2008).

[22] Both these parameters are subjected to extensive sensitivity analysis in Section 6.3.

[23] The productivity parameters A_f and A_s are indices and therefore not directly comparable. While we set $A_f > A_s$, the magnitude of the differential $A_f - A_s$ does not affect the qualitative implications of the model.

[24] The full list of countries used for the reference sample is provided in the Appendix.

Table 6
Permanent shocks: Steady-state changes[a].

	A. Aggregate Effects					
	dK	dC	dY	dp	dV	$d(1-l)$
Remittance Shock ($\Delta R = 1\%$, $\kappa = 0$)	−0.015	+0.046	−0.001	+0.002	−0.001	+0.013
Collateral Shock ($\kappa = 0$ to 0.13, $\Delta R = 0$)	+0.009	−0.029	+0.001	−0.001	+0.422	−0.008
Remittance with Collateral Shock						
a $\Delta R = 1\%$, $\kappa = 0$ to 0.13	−0.006	+0.017	−0.0003	+0.001	+0.425	+0.005
b $\Delta R = 1\%$, $\kappa = 0$ to 0.25	+0.003	−0.009	+0.0002	−0.0004	+0.818	−0.003
	B. Sectoral Effects					
	dK_f	dK_s	dL_f	dL_s	dY_s/Y	dL_s/L
Remittance Shock ($\Delta R = 1\%$, $\kappa = 0$)	−0.028	+0.035	−0.026	+0.047	+0.047	+0.034
Collateral Shock ($\kappa = 0$ to 0.13, $\Delta R = 0$)	+0.018	−0.022	+0.016	−0.029	−0.029	−0.021
Remittance with Collateral Shock						
a $\Delta R = 1\%$, $\kappa = 0$ to 0.13	−0.011	+0.013	−0.015	+0.013	+0.018	+0.012
b $\Delta R = 1\%$, $\kappa = 0$ to 0.25	+0.006	−0.007	+0.008	−0.007	−0.009	−0.006

[a] All changes are reported as percentage deviations from the pre-shock steady-state equilibrium.

employment of the formal sector, and a decline in aggregate GDP. Particularly, the increase in remittances is associated with an increase in (self) employment and the capital stock in the informal sector, while capital allocated to the formal sector declines.[25] The increase in self-employment in the informal sector raises the overall time allocation to work, thereby reducing the consumption of leisure in equilibrium.

With respect to the transitional adjustment of the economy to the permanent remittance shock, the higher inflow of remittances from abroad leads to an instantaneous real appreciation of the exchange rate, which overshoots its long-run equilibrium. On impact, this leads to an upward jump in GDP, by increasing the market value of informal production. However, this increase cannot be sustained over time, and GDP declines steadily to a lower level in the long run. This is because the increase in the relative price of the informal sector good draws both labor and capital into the informal sector, thereby reducing factor productivity in the formal sector. Since the formal sector is relatively more productive than the informal sector, the outflow of labor and capital from this sector more than offsets the gains in the informal sector and, consequently, GDP contracts. Further, the decline in the stock of capital employed in the formal sector more than offsets the corresponding increase in the informal sector, so that the aggregate capital stock also declines, further contributing to the decline in GDP. The higher remittance inflow enables private consumption to increase in the short run, but the decline in output causes consumption to fall in transition, albeit to a net higher level relative to its pre-shock level. The fall in output and the aggregate capital stock reduce the economy's aggregate borrowing needs and this, along with the higher inflow of remittances, leads to an improvement in the economy's net indebtedness.

In summary, a permanent increase in the level of remittance inflows is *expansionary* for the economy in the short run, but *contractionary* in the long-run with the Dutch Disease phenomenon emerging over time. The real exchange rate appreciation caused by the remittance shock leads to a reallocation of resources (both labor and capital) to the less productive informal sector over time, which eventually undermines the short-run expansion in economic activity. [26]

6.2. Collateral effect

The importance of remittances as a collateral in securitizing future borrowing has recently received some attention, especially for countries having a high remittance-to-GDP ratio, as well as those having a large informal sector that otherwise face limited access to capital markets. In this section, we consider a counter-factual policy experiment, where the collateral parameter κ in the borrowing rate function (14) is increased permanently from its benchmark level of 0 (no collateral effect of remittances) to 0.13 (where 13% of existing remittance inflows can be used as a collateral for borrowing). In doing so, we assume that the level of remittances remains unchanged at its benchmark level. This enables us to isolate the pure collateral effect associated with remittances. The results are reported in the second row of Table 5 and illustrated in Fig. 2.

The pure collateral effect generates a dynamic response that is in sharp contrast to that of a pure remittance shock. The long-run effect is now *expansionary*; both the stock of capital and aggregate output increase over time, as do the shares of output and employment in the formal sector. The real exchange rate depreciates in the long-run, with the economy increasing its net indebtedness to the rest of the world. The exchange rate depreciation and the decline in the output and employment shares of the informal sector imply that the collateral policy does not lead to the long-run Dutch Disease effect that is associated with a pure remittance shock.

Fig. 2 depicts the transitional responses to the change in the collateral policy for remittances. The fact that a fraction of current remittance flows can now be used to securitize future borrowing leads to an instantaneous depreciation of the real exchange rate, i.e., a fall in the relative price of the informal sector good. This happens because the higher borrowing and debt-servicing capacity due to the collateral effect releases resources for investment, which is produced in the relatively more productive formal sector. The consequent increase in the demand for labor in this sector leads to an instantaneous decline in the relative price of informal production. Given that sectoral labor and capital cannot respond instantaneously (being state variables), the real depreciation of the exchange rate leads to a short-run decline in aggregate GDP and consumption. The increase in capital accumulation in the formal sector raises the marginal product of labor in that sector, thereby leading to labor (and capital) being re-allocated to the formal sector over time. This enables the formal sector to expand relative to the informal sector and, when combined with the increase in the aggregate stock of capital, increases GDP over time.

Table 6 and Figs. 1 and 2 highlight the sharp differences between the effects of a remittance inflow and those of an associated collateral policy. In particular, while remittances lead to a Dutch Disease effect through a real appreciation of the exchange rate and an expansion of the informal sector, a collateral policy that mobilizes remittances for borrowing purposes has the opposite effect. This contrast raises the interesting question

[25] Woodruff and Zenteno (2007) and Yang (2008) present empirical evidence of migration and remittances boosting both self-employment and investment through the expansion of microenterprises.

[26] A related issue is the extent to which informal employment is prevalent in the formal sector. This is an important consideration, since the main transmission mechanism in our paper deals with the dynamic response of the real exchange rate and its consequences for sectoral resource allocation over time. However, Gibson (2014) provides cross-country evidence that formal enterprises in developing countries account for only 23 percent of all informal employment. As such, the bulk of informal employment can indeed be attributed to informal enterprises.

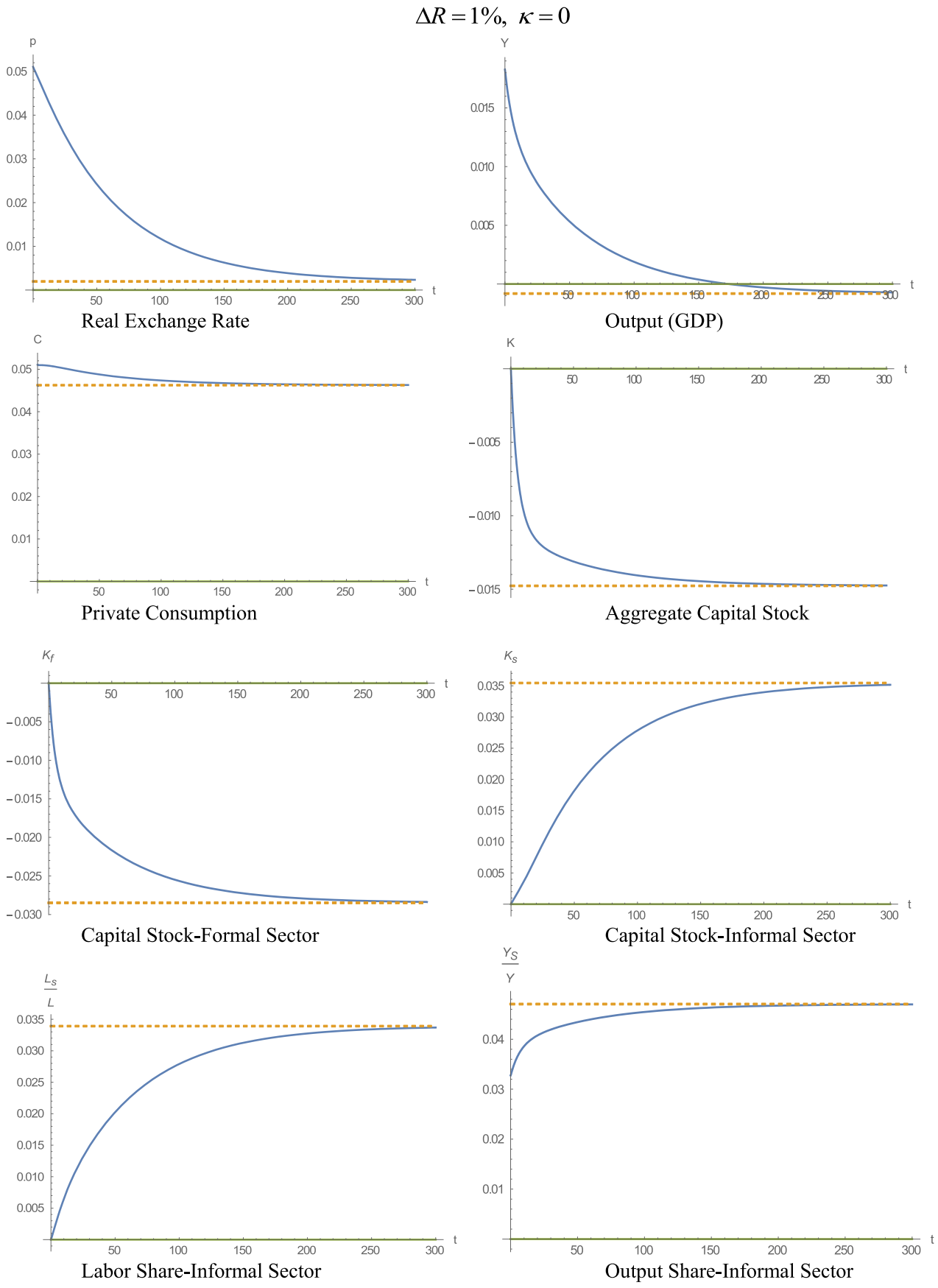


Fig. 1. Permanent exogenous increase in remittances.

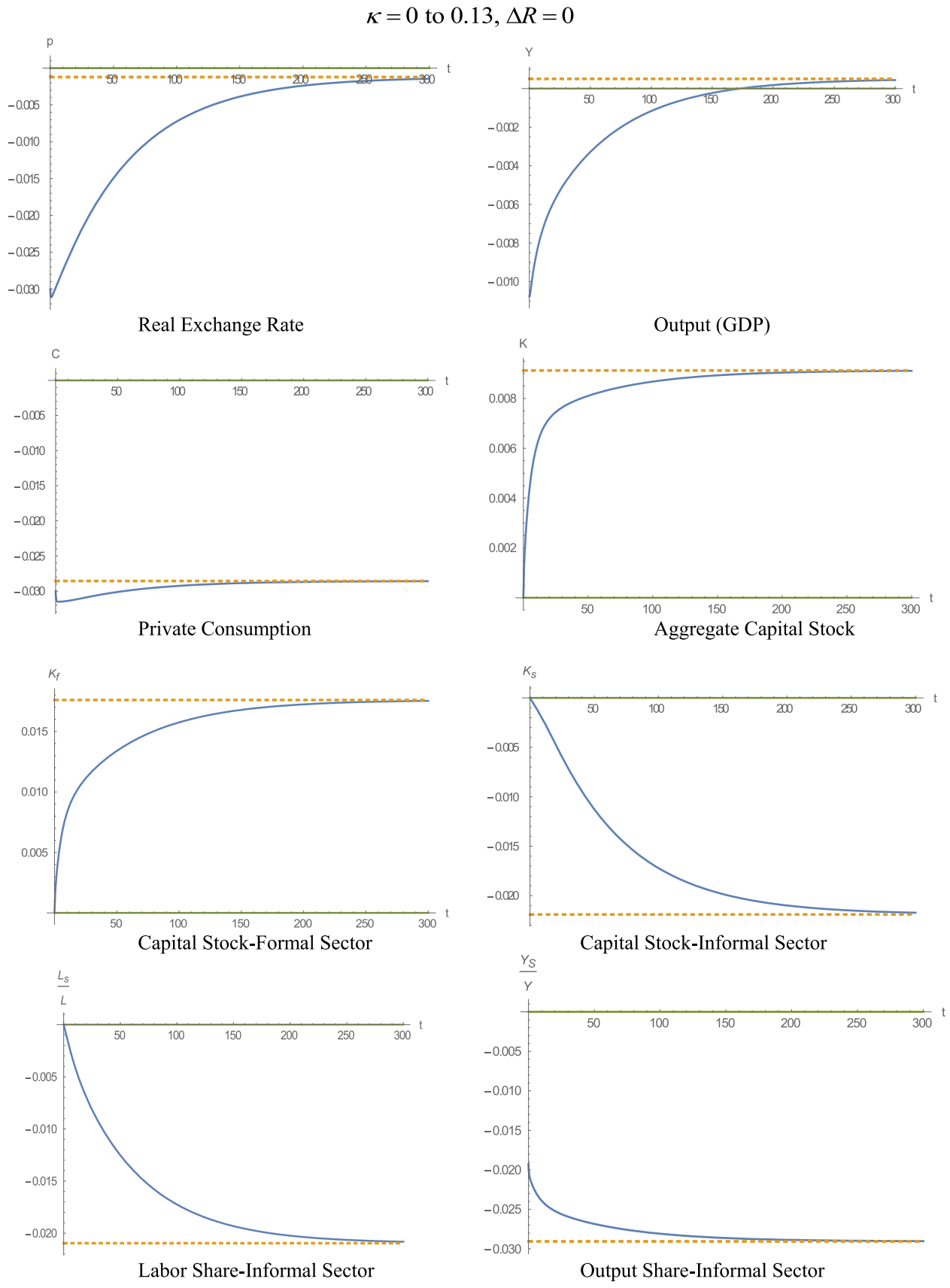


Fig. 2. Collateral effect.

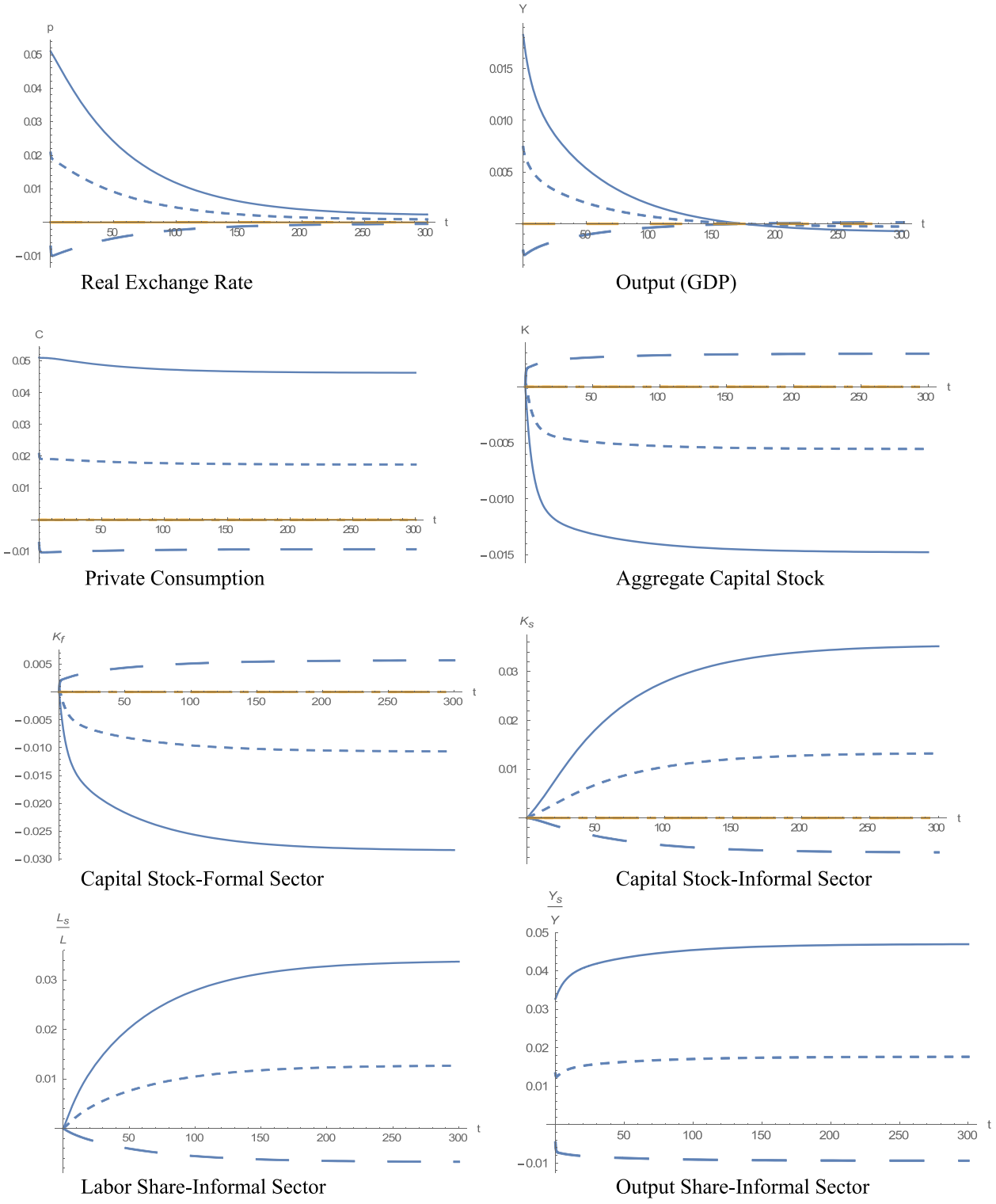


Fig. 3. Permanent exogenous remittance with collateral shock.

of whether an increase in remittances can have an expansionary effect on the economy in the long-run (consequently avoiding the Dutch Disease), if it is accompanied by an appropriate collateral policy. To address this, we consider an exogenous and permanent increase in the level of remittances under two scenarios. In the first, it is accompanied by a small increase in the collateral policy, with κ increasing simultaneously from 0 to 0.13. In the second, κ is increased to 0.25. The results are reported in the third and fourth rows of Table 6 and illustrated in Fig. 3.

From Fig. 3 we see that as the collateral effect becomes stronger, the instantaneous real appreciation of the exchange rate following a remittance shock becomes weaker, with a real depreciation occurring for the case where $\kappa = 0.25$. When the collateral effect is relatively weak, i.e., when $\kappa = 0.13$, the long-run contractionary effect of remittances dominates, although it is alleviated somewhat. However, increasing κ further to 0.25 confirms that an increase in remittances that is accompanied by a sufficiently large change in the recipient economy's collateral policy can indeed have a long-run expansionary effect, and avoid the long-run Dutch Disease phenomenon. Output and private capital increase, while the share of the informal sector declines over time.

This example highlights the potential importance of the collateral effect in enhancing the economy's productive capacity when faced with an increase in remittance inflows. The collateral effect, through the depreciation of the real exchange rate, diverts resources towards the more productive formal sector, as opposed to a pure increase in remittances. Further, from a policy perspective, these results underscore the importance of the collateral effect in reducing the relative size of the informal sector in a developing economy.[27]

6.3. Sensitivity analysis

In this section, we examine the sensitivity of the main results to variations in the following structural parameters: (i) the intersectoral mobility cost for capital, h, (ii) the intersectoral mobility cost for labor, χ, (iii) the rate of exit from employment to leisure, z, and (iv) the rate of entry from leisure into employment, σ. The results of our sensitivity analysis are reported graphically, in Fig. 4. We consider the case of a one percent exogenous and permanent increase in the level of remittances, with no change in the country's collateral policy. For the intersectoral capital mobility cost, h, we consider the values $h = 5$, 15, and 30, reflecting low, baseline, and high costs of moving capital from the formal to the informal sector. Correspondingly, for the labor mobility cost parameter, we use $\chi = 5$, 15, and 30. For the exit and entry rates from and into employment, z and σ, we consider a low value of 0.01 and a high value of 0.1, in addition to their respective benchmark specifications.

We report the dynamic responses of four key macroeconomic variables for variations in each structural parameter, namely the real exchange rate, aggregate output (GDP), the employment share of the informal sector, and the output share of the informal sector. Qualitatively, Fig. 4 suggests that the model's transitional dynamics with respect to a remittance shock are remarkably robust to variations in these key structural parameters.[28] Another issue is the degree of imprecision in the empirical measurement of the relative size of the informal sector in GDP. This can potentially lead to problems in interpreting the movements of formal output and aggregate output. In all the experiments we consider, these two variables move together in transition, i.e., an increase (decrease) in aggregate GDP is associated with an increase (decrease) in the share of formal production.

7. Temporary shocks

While the permanent changes considered in Section 6 are important to pin down the intrinsic mechanisms of the model, temporary shocks are arguably more realistic. In this section, we consider changes in the level of remittances and collateral policy that are temporary in nature. In this respect, an important consideration is whether the nature of the dynamic response of the recipient economy depends on the duration of the underlying shock. We examine the following three temporary shocks: (i) an exogenous increase in remittances, (ii) an increase in remittances accompanied by a change in the collateral policy, and (iii) a countercyclical increase in remittance inflows, driven by an aggregate negative productivity shock. In each case, we assume that the underlying shock lasts for one period. Fig. 5 plots cases (i) and (ii) above, and Fig. 6 plots case (iii).

7.1. Increase in remittances

Fig. 5 plots the dynamic response for a temporary and exogenous increase in the level of remittances by one percent from its benchmark level (solid line). Comparing the economy's response to this temporary shock with its permanent counterpart in Fig. 1, we see that the duration of the shock has a critical effect on its dynamic absorption. In sharp contrast to the permanent shock, a temporary increase in remittances leads to an instantaneous depreciation of the real exchange rate, as the household internalizes the fact that the inflow will last for only one period. Consequently, aggregate GDP contracts, as does the share of output of the informal sector. The decline in GDP leads to a fall in consumption and decumulation of capital in both sectors. The household offsets for this decline by increasing self-employment in the informal sector. Once the duration of the temporary shock is over, the economy begins its transitional adjustment back to the baseline steady-state equilibrium. The household, knowing that the increase in remittances is temporary, uses the temporary resources to pay down its outstanding debt (the current account improves; not shown).

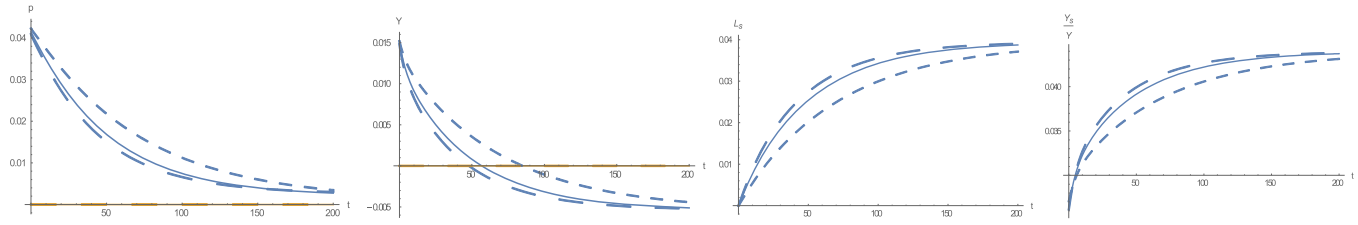
In summary, while a permanent increase in remittances is expansionary for the economy in the short run, but contractionary in the long-run, a temporary increase has the opposite effect, with the economy contracting in the short run before adjusting back to its pre-shock equilibrium. Further, while a permanent increase in remittances leads to a real exchange rate appreciation, a temporary inflow of remittances has the opposite effect: a depreciation of the real exchange rate. As such, we can conclude that the Dutch Disease phenomenon associated with remittance inflows is driven by its duration: the more persistent remittance inflows are, the more likely they are to generate the Dutch Disease in equilibrium.[29]

[27] A possible offset to the role of the collateral effect in reducing the relative size and employment share of the informal sector can lie in the composition of the additional borrowing that is facilitated. For example, if informal production is characterized by microenterprises that can get enhanced access to international capital markets, then the inflow of additional resources can crowd out investment in the formal sector. Also, if the share of informal employment in the formal sector is substantial, then the results obtained in Section 6.2 may be weakened. Although this channel may have adverse consequences for aggregate GDP, the response of total employment is difficult to predict a priori, since the employment share of the informal sector is large relative to its corresponding share in GDP. While these issues are beyond the scope of this paper, they may be potentially important considerations for future research.

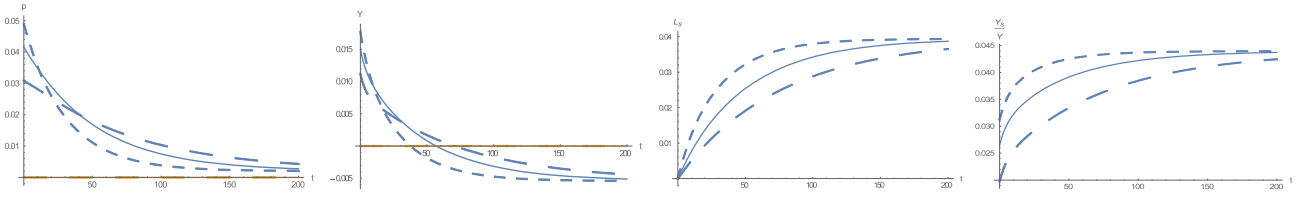
[28] In each case, we assume that the economy starts from the baseline pre-shock equilibrium with the parameterization described in Table 4, except for the parameter which is subject to the sensitivity check. All plots in Fig. 4 represent percentage deviations from the pre-shock steady state equilibrium.

[29] It is instructive to relate our results on a temporary shock of remittance inflows with similar exercises conducted in Mandelman (2013) and Finkelstein Shapiro and Mandelman (2016). Mandelman (2013) uses a New Keynesian DSGE framework with heterogeneous households (Rule-of-thumb and Ricardian) and, consequently, the short-run behavior of the real exchange rate is driven by the presence of sticky prices. In our model, prices are flexible, but intersectoral factor mobility is not, and the response of the real exchange rate is consequently driven by this inflexibility in factor markets. Our results are more consistent with Finkelstein Shapiro and Mandelman (2016), who study the relationship between remittances and self-employment. However, while the real exchange rate plays a critical role in the propagation of the transitory remittance shock in our model, it is absent from their analysis, with the economy's response instead being guided by the response of self-employment.

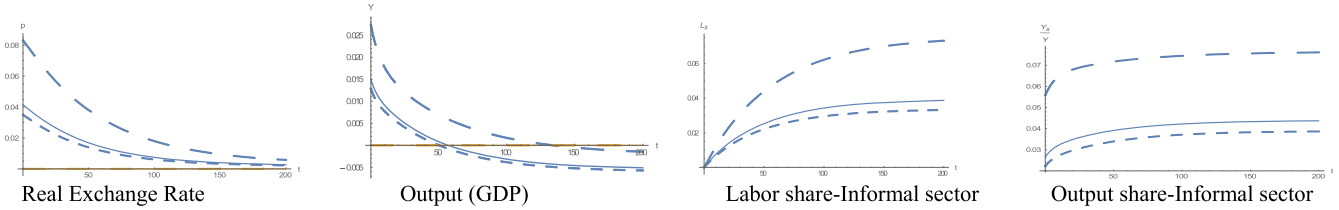
A. Intersectoral Capital Mobility Cost (h)



B. Intersectoral Labor Mobility Cost (χ)



C. Exit Rate from Employment (*z*)



D. Entry Rate into Employment (σ)

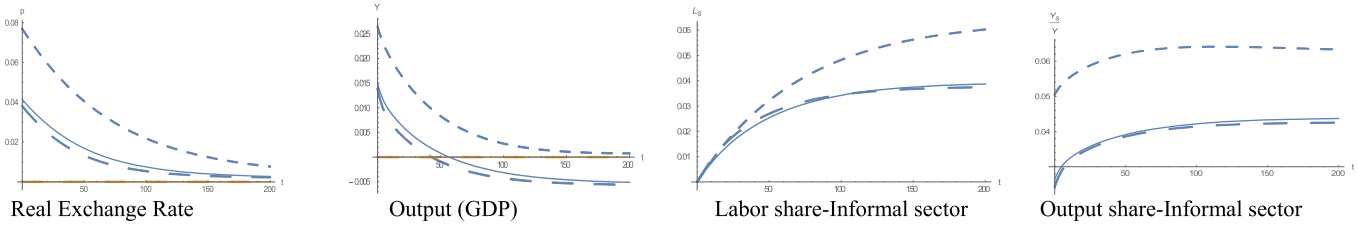


Fig. 4. Sensitivity analysis.

7.2. Collateral effect

The dashed plots in Fig. 5 depict the case of a temporary increase in remittances which is accompanied by a temporary change in the collateral policy, with κ increasing from 0 to 0.25 for the duration of the shock. When the remittance shock is accompanied by a collateral policy, the economy's response is now expansionary in the short run, with output, consumption, sectoral capital stocks increasing on impact. The presence of a collateral effect magnifies the amplitude of the aggregate economy's response: the transitional increases in the stock of capital, consumption, GDP, and the real exchange rate are significantly larger than for the case of a pure remittance shock without the collateral effect. The formal sector, being more productive draws more capital and labor because of the collateral effect. This causes the employment and output share of the informal sector to decline in transition. In summary, while a pure and temporary remittance shock leads to a temporary contraction for the economy, the presence of an accompanying collateral effect works in the opposite direction, by enabling a short-run expansion of economic

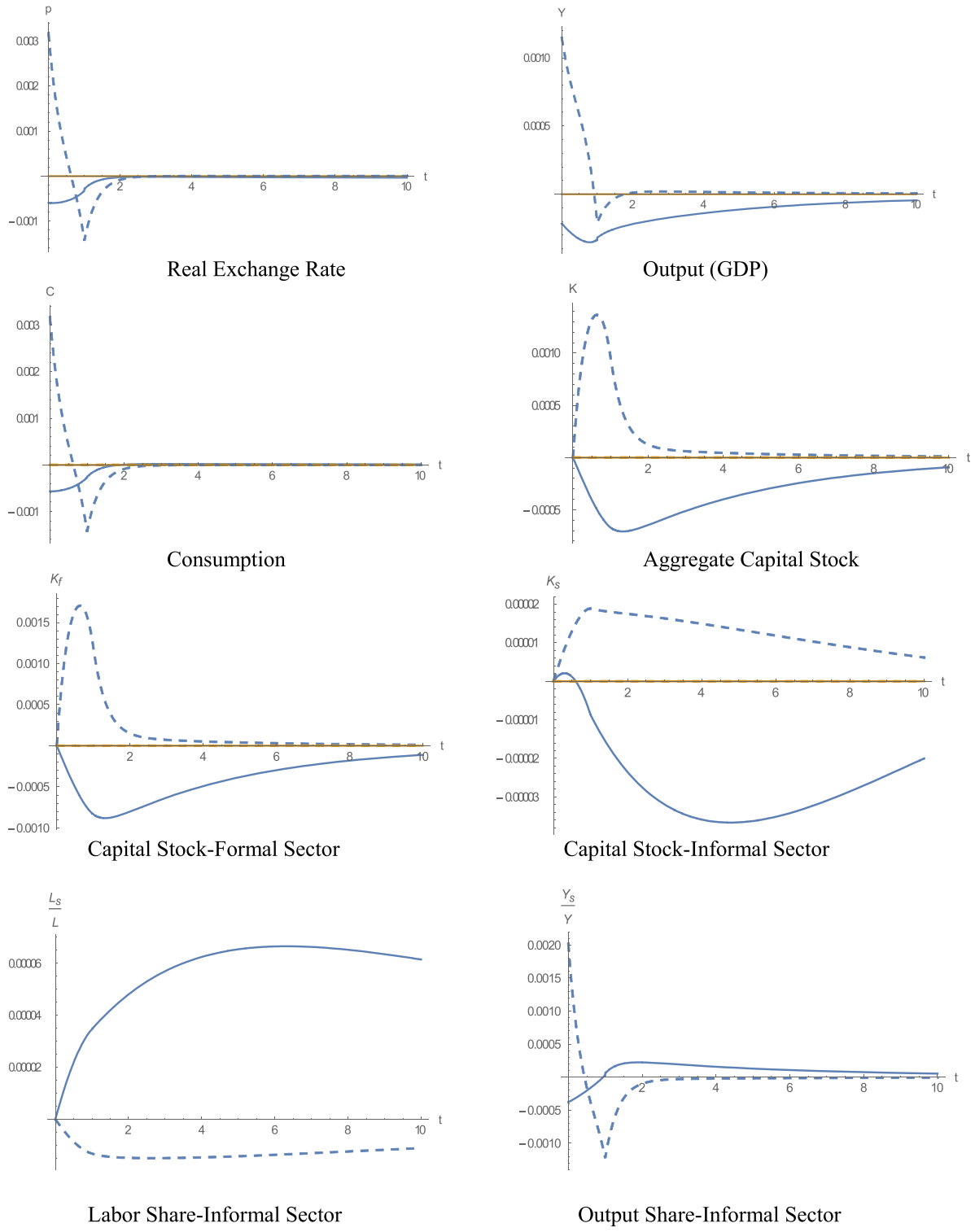


Fig. 5. Temporary remittance (exogenous) and collateral shock.

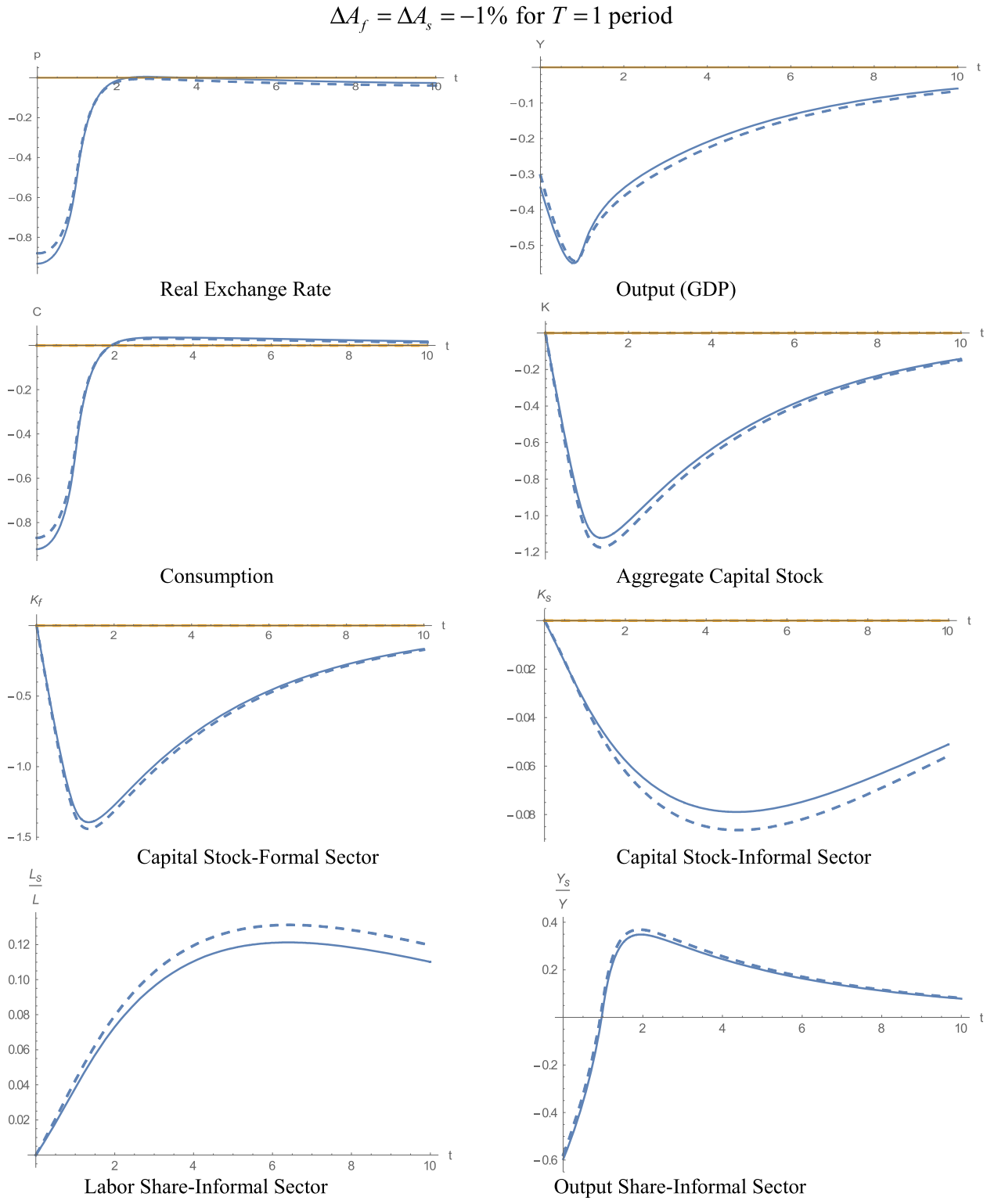


Fig. 6. Temporary Negative Productivity Shock vs. Countercyclical Remittance Shock.

activity, and reducing the share of the informal sector.

7.3. Endogenous (countercyclical) remittances

Thus far, we have considered the impact of exogenous remittances, where inflows are independent of economic conditions in the recipient country. More recently, several authors, including Yang (2008), Acosta et al. (2009), Durdu and Sayan (2010), Mandelman (2013), and Finkelstein Shapiro and Mandelman (2016) have pointed to the countercyclical nature of remittance inflows. Specifically, they suggest that remittance inflows from overseas residents are likely to increase if families or recipients back home (in the host country) face an unexpected economic hardship. This can be captured by means of an unanticipated temporary negative productivity shock that impinges on the recipient economy, which leads to an increase in the inflow of remittances for its duration. As such, countercyclical remittances can be a form of insurance against an unanticipated negative shock in the recipient economy. Following Acosta et al. (2009), we formulate this as

$$R = \overline{R} + R^c \tag{20}$$

In (20), $\overline{R}$ represents the exogenous component of remittance inflows, as in our specification so far, and R^c denotes the endogenous or countercyclical component, given by $R^c = Y^{\varphi}$, where the parameter φ is the elasticity of the countercyclical component of remittances to GDP. Acosta et al. (2009) estimates this parameter to be about -2.5 for El Salvador, while Mandelman (2013) estimates a value of -1.98 for Philippines, both of which are high remittance-recipient countries. We therefore set $\varphi = -2$ in (20) as a reasonable approximation for this elasticity parameter.

We consider a temporary aggregate negative productivity shock, where the benchmark productivity levels in each sector decline temporarily by one percent for one year.[30] Fig. 6 plots the dynamic response in two cases: (i) when there is no countercyclical component to remittances (solid line), and (ii) when remittances are countercyclical as in (20), and increase temporarily on impact of the negative productivity shock.

Since the underlying productivity shock is negative, the economy goes through a contraction in transition, with capital, consumption, and output declining temporarily from their steady-state levels. Since the formal sector is relatively more productive than is the informal sector, an aggregate negative productivity shock causes the real exchange rate to depreciate on impact, which leads to an instantaneous decline in both GDP and the output share of the informal sector. The lower aggregate output leads to a decline in consumption and a decumulation of capital in both sectors. Also, the fall in the capital stock in the formal sector exceeds that in the informal sector and hence the marginal product of formal employment declines more than that of informal employment. This drives up the share of employment in the informal sector in transition, underscoring its countercyclical behavior.

When the negative productivity shock is accompanied by an increase in countercyclical remittance inflows, the initial depreciation of the real exchange rate is reduced, since the larger remittances provide a buffer against the relative decline in the productivity of the formal sector. Consequently, the instantaneous declines in GDP and consumption are also slightly smaller with a countercyclical remittance shock, pointing to a (small) business-cycle smoothing effect of remittances. The mechanism that ultimately helps smooth some of the contractionary fluctuations from the productivity shock is a larger increase in the share of informal employment from the countercyclical remittance shock. The lower demand for labor in the formal sector is more than offset by an increase in informal (self) employment, enabling the household to offset for some its income and consumption losses from the negative productivity shock. Additionally, since the higher remittance inflow following the negative productivity shock provides an additional income buffer to the household, the resulting increase in leisure (not shown) lowers the quantitative magnitude of the business cycle smoothing effect. In fact, it can be shown that this smoothing effect is stronger when the labor-leisure margin is absent.[31]

8. Conclusions

Developing countries that receive a large share of their GDP in the form of external transfers such as remittances are also typically associated with large informal sectors that absorb, on average, around 50 percent of their labor force and account for more than a third of their GDP. We develop a two-sector open economy model that characterizes many of the features of these economies, such as the costly (and sluggish) movement of capital and labor between the informal and formal sectors, the counter-cyclicality of informal employment, and the lack of tax collection in the informal economy. Within this context, we examine the dynamic absorption of remittance inflows, both permanent and temporary, as well as the effect of remittances serving as a collateral for borrowing. In addition, we also consider the case where remittance inflows may be endogenous, being driven by productivity shocks in the recipient economy.

By embedding remittances and the informal sector in a dynamic general equilibrium model, we bridge two important areas of research in development economics. On the one hand, the literature on the informal economy has focused mainly on the issues of size, measurement, and tax avoidance and enforcement, largely ignoring the issue of external transfers. On the other, the literature on remittances has dealt with their macroeconomic effects on the aggregate (or formal) economy, without reference to their implications for the informal sector. Our paper is the first systematic approach in bringing these two areas of work together. Further, there is a general lack of consensus in the empirical literature on the aggregate effects of remittances, with some studies finding a positive association between remittances and economic activity, while others documenting a negative or ambiguous relationship. By characterizing the different ways in which remittances may impinge on a recipient economy, our paper attempt to reconcile the variety of results in the corresponding literature. In addition, we analyze a potential role for remittances in serving as collateral to securitize debt at the aggregate level, an important feature that has not yet been studied systematically in the literature.

Our analysis has abstracted from several other important features that may characterize the relationship between international transfers and the informal economy. One issue of particular relevance is the share of labor employed in the agricultural sector, which tends to be informal, while its output is tradable, thereby introducing offsetting effects to those we have been emphasizing. The reason why this is potentially relevant is because the sample of the 56 countries we cite in the Appendix suggests extreme variations in the relative share of agricultural employment in these economies.[32] To capture the impact of agricultural employment in detail would require expanding the model appropriately and is beyond the scope of this paper. Some preliminary idea of the role of agricultural employment can be gleaned by considering the likely impact on the productive elasticity of labor (η), in the informal sector. To the extent that the informal sector incorporates agriculture, and land substitutes for capital in production, there may be little effect.[33] Other issues that merit

[30] Note that even though we simulate an aggregate negative productivity shock, since $A_f > A_s$ by construction, the productivity decline in the formal sector is larger than in the informal sector. Another way to rationalize this asymmetry is that developing countries tend to be more vulnerable to external shocks, which impinge more on the tradable (formal) sector. An alternative specification would be to assume that the productivity of the informal sector is imperfectly correlated to that of the formal sector, as in Fernandez and Meza (2015). Our results remain qualitatively unaffected with this alternative specification, as long as $A_f > A_s$.

[31] This result is demonstrated in a previous version of this paper where the labor-leisure choice was absent.

[32] Estimates range from under 10% in countries like Iceland, South Africa, and Argentina to over 50% in countries like India, Kenya, and Guinea (Source: WDI).

[33] However, the alternative scenario where land substitutes for labor will likely to lead to a reduction in η. Sensitivity analysis with respect to this parameter reported in a previous version of this paper suggests that results are robust with respect to variations in this parameter below its benchmark value of 0.75.

further analysis include (but are not restricted to) the skill composition of the labor force, formal entry barriers into the labor market, public-sector inefficiencies, borrowing constraints for households, and tax enforcement. These are all undoubtedly important considerations, and we intend to pursue them in future research.

Appendix

Reference Sample of Countries

Algeria	Maldives
Argentina	Mali
Azerbaijan	Mauritius
Bangladesh	Mexico
Belize	Mongolia
Benin	Morocco
Bolivia	Nepal
Botswana	Nicaragua
Brazil	Niger
Bulgaria	Nigeria
Burkina Faso	Pakistan
Cameroon	Panama
Colombia	Paraguay
Congo, Dem. Rep.	Peru
Costa Rica	Philippines
Dominican Republic	Romania
Ecuador	Solomon Islands
Egypt, Arab Rep.	South Africa
Estonia	Sri Lanka
Gambia, The	Syrian Arab Republic
Guatemala	Thailand
Guinea	Togo
Honduras	Tunisia
Iceland	Uganda
India	Uruguay
Indonesia	Zambia
Kenya	
KyrgyzRepublic	
Malawi	
Malaysia	

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