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### ► **To cite this version:**

Eric Darmon, Laetitia Chaix, Torre Dominique. M-payment use and remittances in developing countries: a theoretical analysis. *Revue d'économie industrielle*, 2016, *L'économie numérique en question*, 156, pp.159-183. <10.4000/rei.6469>. <halshs-01576774>

**HAL Id: halshs-01576774**

**<https://shs.hal.science/halshs-01576774v1>**

Submitted on 21 May 2024

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## M-payment use and remittances in developing countries: a theoretical analysis

*Transferts monétaires des migrants et paiement mobile dans les pays en développement : une contribution théorique*

Eric Darmon, Laetitia Chaix and Dominique Torre

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### Electronic version

URL: <https://journals.openedition.org/rei/6469>

DOI: 10.4000/rei.6469

ISSN: 1773-0198

### Publisher

De Boeck Supérieur

### Printed version

Date of publication: 31 December 2016

Number of pages: 159-183

ISBN: 9782807390584

ISSN: 0154-3229

### Electronic reference

Eric Darmon, Laetitia Chaix and Dominique Torre, "M-payment use and remittances in developing countries: a theoretical analysis", *Revue d'économie industrielle* [Online], 156 | 4e trimestre 2016, Online since 31 December 2018, connection on 03 June 2022. URL: <http://journals.openedition.org/rei/6469> ; DOI: <https://doi.org/10.4000/rei.6469>

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# M-PAYMENT USE AND REMITTANCES IN DEVELOPING COUNTRIES: A THEORETICAL ANALYSIS

Eric Darmon\*, Laetitia Chaix† and Dominique Torre‡

 **Keywords:** mobile-payment, M-payment, remittance flows.

 **Mots-clés :** paiement mobile, M-paiement, transferts monétaires.

## 1. INTRODUCTION

According to the World Bank (2014)<sup>1</sup>, “there should be a strong relationship between remittance flows and financial inclusion. A key reason is that remittances are usually regular and predictable flows, which should, in principle, make remittance recipients relatively more inclined to join the formal financial sector”.

It has been claimed also that remittances represent the most important financial transactions for people with limited access to banking services. These claims are based on two stylized facts observed in many developing countries, namely relatively low access to banking services, and relatively high levels of remittance flows.

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1 Global Financial Development Report 2014 : Financial Inclusion

In 2014, more than 2.5 billion people lacked a bank account, with the banking service penetration rates observed in developing countries.<sup>2</sup> This number decreased by 20% between 2011 and 2014 (Demiguc-Kunt, Klapper, Singer, Van Oudheusden, 2014), despite multiple costs incurred by opening and holding a bank account: transport costs (e.g. in countries with poor infrastructure), administrative costs (i.e. the level of paperwork especially in countries with low levels of literacy); and service costs (charges associated with regular or exceptional banking operations). The poor development of banking services is due to demand-side factors such as lack of users' skills, and users' attitudes and behaviors. It is due also to supply-side factors such as the high barriers to entry and low profitability associated with setting up a dense network of bank subsidiaries in rural and sparsely populated areas.

In such context, the diffusion of mobile payment or M-payment services (further M-payment) has been promoted to overcome some of these challenges. M-payments are payments for goods, services, bills and invoices via a mobile device, such as a mobile phone, smart-phone, or PDA (personal digital assistant), exploiting mobile telecommunications networks or close technologies (Dahlberg *et al.*, 2008). The M-pesa experience in Kenya is often cited as an example of the successful diffusion of M-payment (Jack and Suri, 2011). The M-pesa service was launched in 2007 by the operator Safaricom. It allows M-transfers, M-payments (e.g., airtime purchase, mobile ticketing, bulk payments) and M-banking services (e.g., micro-savings, Automated Teller Machine withdrawals). It is used by more than 70% of Kenyan adults (Andrianaivo and Kpodar, 2011) and by 50% of poor, unbanked and rural populations (Alexander, 2010).

According to the World Bank's Global Findex Index (Demiguc-Kunt *et al.*, 2014), in "Sub-Saharan Africa, [...] mobile money accounts drove the growth in overall account penetration from 24 percent in 2011 to 34 percent in 2014" (Demiguc-Kunt *et al.*, 2014, p. 13). The same World Bank report points out that in this region, between 2011 and 2014, more than 10% of the population chose to open a mobile money account managed by a non financial institution either alone or in collaboration with a financial institution. In these countries, mobile money could be a key driver of the observed growing financial inclusion.

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<sup>2</sup> Data available at <http://datatopics.worldbank.org/financialinclusion/>

Anecdotal evidence suggests that the use of mobile services is particularly widespread in countries that are characterized by low levels of banking facilities. The intuition is that M-payment services alleviate both supply and demand constraints. On the one hand, the equipment required by users to implement M-payment exchanges is minimal for users since most people are equipped with mobile phones and are familiar with their use. Sometimes described as a “frugal innovation” (see Bhatti *et al.* 2013), this feature of M-payment services lowers user adoption costs. On the other hand, the technologies used to implement M-payment rest on wireless communication networks and exhibit strong characteristics of ubiquity. From a supply-side perspective, this reduces the geographical constraints especially since the network investment required to supply mobile telecommunication services and M-payment services are complementary service.

The second stylized fact in many developing countries refers to the role played by remittance flows for domestic economies. In October 2015, the World Bank counted 579,809 million remittance flows worldwide (with an annual 4% increase).<sup>3</sup> According to the World Bank Group Factbook (2016), between 2006 and 2014 remittance flows to developing countries increased by 77.7%.<sup>4</sup> 232 million people (3.2% of the world’s population) live and work outside their home countries and the number of international remittances in 2014 reached 528 billion, of which 72% (378 billion) went to low and middle income countries (World Bank Group, 2016).

Remittance flows are generated mainly by high migration, satisfy several economic objectives (consumption, investment, insurance), and can have diverse economic impacts on home countries (Martinez, Cumming, and Vaaler, 2015). On the basis of these trends, the World Bank suggests the existence of a positive relationship between remittance flows and financial inclusion on the one hand, and between M-payment use and financial inclusion on the other. However, to the best of our knowledge, no theoretical analysis has attempted to delve deeper into this general claim. At the

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3 Sources: October and April 2015 versions of World Bank Bilateral Remittance Estimates for 2013 using Migrant Stocks, Host Country Incomes, and Origin Country Incomes.

4 <http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1199807908806/4549025-1450455807487/Factbookpart1.pdf>

macroeconomic level, it has been argued that the increase in remittance incomes might be explained by the reduced transaction costs caused by technological improvements (Giuliano and Ruiz-Arranz, 2009). However, the theoretical literature makes no explicit link between M-payment use for internal transactions and that of remittance flows. This paper tries to fill this gap by elaborating two original features.

First, we focus on the use and impact of M-payment for consumption purposes. We consider the introduction of an M-payment service to achieve within-country, distant person-to-person transactions. We hypothesize that the introduction of M-payment generates new consumption opportunities for the remittance receiver in the home country. Previous work (Aker and Mbitti, 2010, Jack and Suri 2011, Aker *et al.*, 2014, Flood *et al.*, 2013) shows that the use of M-payment services reduces spatial constraints by enabling distant payments which in turn, generates new consumption and investment opportunities. Prior to the introduction of M-payment, such trades were possible but were limited in scope due to their high intermediation costs and poorly developed banking sectors. Thus, the ubiquity of M-payment services reduces geographical constraints by allowing more secure and efficient financial exchanges.

Second, we propose an integrated framework which endogenizes the remittance decision of the remitter located outside the home country. In our model, remittances are used for consumption, from which the remittance receivers derive utility. We assume also that the decision to send a remittance to a domestic household is altruistic: the remittance sender takes into account in his/her utility the utility gained by the remittance receiver when he/she uses the remittance.

These two features are introduced in a two-step game in which first migrant agents decide on the level of the remittance sent to the domestic agents, and second, the domestic agents decide to spend this remittance using M-payment or cash. We confirm theoretically the empirical microeconomic findings in Munyegera and Matsumoto (2016) which find a positive effect of mobile payment on household welfare and explain that domestic agents receive remittances more frequently with a total value higher than that of non-user agents. We also find two sets of macroeconomic results. First, we show that introducing M-payment has a positive effect on aggregate remittance flows, and on welfare. We observe no

crowding out effects in the form of lower levels of remittances due to their improved use allowed by M-payment. Second, we analyze the role of two key parameters (cost of use of cash, cost of M-payment services) on the outcome with M-payment. The cash cost-of-use has expected impacts in terms of diffusion of M-payment and welfare. However, the impact of the M-payment services cost is ambiguous. We find that an increase in their price has two opposite effects. First, it lowers the equilibrium adoption rate of M-payment; second, individual remittances sent by migrant agents increase, providing a kind of “compensation” effect.

Section 2 summarizes the relevant literature. Section 3 presents the theoretical framework, and section 4 presents the results. Section 5 concludes.

## 2. RELATED LITERATURE

Our research topic is related to two bodies of literature dedicated respectively to remittances and M-payment. The economic literature on remittances analyzes both the motives for sending a remittance, and the economic impact of remittances. First, the motivations for sending remittances can be diverse (Yang, 2011). Lucas and Stark’s (1985) seminal study indicates that these motivations range from altruism to self interest with various mixes of the two motivations also possible. Frequently, migrant agents send money home to increase the quality of life of their origin families (Al Mamun *et al.*, 2015). They “derive a positive utility from the well-being or consumption level of the famil[ies] left behind” (Piracha and Saraogi, 2011). In this paper, we focus on this motive but other motives have also been considered. For instance, Agarwal and Horowitz (2002) add an insurance motive: for the domestic family the remittance becomes an insurance tool to protect against income shocks by diversifying its sources of income (Yang and Choi, 2007). In other cases, remittances are used to invest in the home country: the migrant agent and his/her family can use them to accumulate savings, or to acquire financial or more frequently, physical assets (Bounie, Diminescu, Francis, 2013). In this case, it is more difficult to distinguish altruism from self interest in the migrant agent.

There is also a stream of literature on the economic effects of remittances (Chami *et al.*, 2008a, Guha, 2013) positioning the macroeconomic

relationship between remittances and economic growth as central (Goschin, 2014, Jouini, 2015). In most cases, remittances are shown to promote economic growth (Chami *et al.*, 2008b). According to Yaseen (2012), remittances impact on growth through two channels: financial development, and institutions. The remittances received relieve credit and insurance constraints and increase household income (Atamanov, Van Den Berg, 2012). Remittances contribute to financial development which may interact with growth (Gupta, *et al.*, 2009, Le, 2011, Imaia, Gaihab, Alia, Kaicker, 2014, Kumar, 2013). According to Ziesemer (2012), remittances have a positive effect not only on the level and growth of per capita GDP but also on savings rates and public expenditure on education, while decreasing tax revenues and emigration. However, this positive effect on growth has been disputed (Jouini, 2015). For instance, Chami *et al.* (2008a) find a significant negative influence on economic growth, reasoning that remittances might allow domestic families to remain inactive which would slow the development of human capital in the home country. Remittances also accelerate financial inclusion (Anzoategui *et al.*, 2014) and have a positive effect – at least in the short term – on both poverty and financial development (Gupta *et al.*, 2009).

The second body of literature refers to the economics of mobile money that include both issues in monetary economics and industrial organization. From a theoretical perspective, it makes reference to the literature dealing with the choice between cash and other types of assets without supposing any cash-in-advanced constraint (Whitesell, 1989, Arango, Bouhdaoui, Bounie, Eschelbach and Hernandez 2016, Alvarez and Lippi, 2015). An original feature of the choice of mobile money against other means of payment is that, like the type of money use in search based models, M-payment can only be used if both partners agree on acceptance and use of it. Put differently, as the use of M-payment is not generalized, the choice to adopt it is then mainly determined by the choice of other agents to use it.

The diffusion of mobile money has likely enabled millions of people who otherwise would have been excluded from the formal financial system, to perform financial transactions. In countries with low levels of penetration of banking facilities, M-payment can compensate partially by providing secure, simple, and rapid banking services (Chaix, Torre, 2015). It has been documented that the banking industry faces huge difficulties when

expanding to developing countries with largely unbanked rural populations (Assadi, Cudi, 2011). In those countries, development of a retail network (subsidiaries, money transport) entails high fixed costs which can deter entry to some areas (De Sousa, 2010). Mobile telecommunication networks provide an alternative and cheaper way to implement banking transactions (Granata *et al.*, 2014). To enhance success, governments and policy need to introduce light regulation to increase the supply of mobile money, while also imposing rules enforcing a certain level of interoperability (Evans, Pirchio, 2015, Ky, 2015).

To our knowledge, the only paper which considers both remittances and M-payment is Munyegeera and Matsumoto (2016). They propose an empirical analysis of the effects of use of mobile money services on household welfare in developing countries. They use household survey panel data from rural Uganda for the 2009-2014 period. They apply a combination of household fixed effects, instrumental variables, and propensity score matching methods. They find a positive and significant effect of access to mobile money on household welfare, as measured by real per capita consumption. The mechanism driving this impact is the facilitation of remittance: households using mobile money services are more likely to receive remittances, to receive more frequent remittances, and to receive higher value remittances than non-user households do.

Our paper contributes to this body of work by considering the interplay between remittances and use of new payment services in the receiver country, an issue which so far has not been studied theoretically. In our framework, the level of the individual remittance depends on the subsequent consumption opportunities which in turn, are influenced by the available payment technology. Among the various motivations for sending a remittance, we focus on the role of altruism since this appears to be a central motivation if the remittance is used for consumption. We contribute also to the literature on adoption of M-payment: our model captures, in a simple way, the change in consumption decisions enabled by M-payment technology, and analyze how the use of M-payment can drive the switch from trades implemented at the local scale to trades implemented on a wider scale. Another original feature of our model is that we consider the decisions of both remitters and receivers, and evaluate the welfare of remitters'/receivers' families in this context, prior to and after the introduction of M-payments.

### 3. THE THEORETICAL SETTING

To analyze the impact of M-payment use on the remittance and consumption decisions, we build an original framework which accounts for both the remittance decision and the use of the remittance for consumption, with M-payment or with traditional exchange means (*i.e.* cash).

We consider the choices made by  $n$  households. Each household  $i$  is composed of domestic agents *i.e.*, family/relatives located in the domestic country (referred to as domestic agents) and of migrant agents *i.e.*, the network of family/relatives living outside the country (referred to as migrant agents). Migrant (resp. domestic) agents are remitters (resp. receivers).

In a first step, the migrant agents of household  $i$  ( $i = 1 \dots n$ ) send a remittance  $r_i$  ( $r_i \geq 0$ ) to domestic agents  $i$ . In a second step, the domestic agents  $i$  of household  $i$  receive this remittance and face various consumption opportunities depending on use of M-payment.<sup>5</sup> This defines a two step game which is solved by backward induction.<sup>6</sup>

#### 3.1. Step 2 (domestic agents) : M-payment use and consumption opportunities

##### 3.1.1. Consumption opportunities

At step 2, the domestic agents  $i$  receive a remittance  $r_i$  ( $r_i \geq 0$ ) and face two potential consumption opportunities.<sup>7</sup> Domestic agents  $i$  can consume goods bought either distantly or locally. Distant consumption opportunities relate to all transactions that cannot be implemented without a previ-

5 Note that we here focus on internal uses of M-payment. Thus, we do not consider here the channel through which the remittance is sent (see *e.g.* Kosse and Vermeulen (2014) and Siegel and Lücke (2013) on this issue)

6 A practical implication of the structure of the game is that migrant agents are aware of the subsequent level of the domestic agents' utility enabled by their remittances. This can be done either informally or by use of communication devices that allows for information exchange.

7 Since the model focuses on the interplay between M-payment use and remittances, we do not need to consider other sources of revenue for domestic households.

ous physical cash transfer. For instance, consider a person-to-person trade. If this trade is local (e.g., the two persons live in the same geographical area and there are no transportation costs *stricto sensu*), the transaction and the payment are simultaneous, and cash is sufficient. However, if these two persons are physically distant, there is a need to secure the transaction before the good is produced or exchanged, and use of cash might inhibit such transactions.<sup>8</sup> The transaction costs are usually so high as to discourage cash transactions in such cases.

For simplicity, we assume linear preferences: for each unit of expense, domestic households obtain a utility level  $k_l$  (resp.  $k_d$ ) from consumption of goods bought locally (resp. distantly). Starting from a situation in which exchanges essentially are local because of lack of payment means to achieve distant trade, goods bought distantly are a way for households to diversify their consumption set compared to a locally-constrained basket set. Thus, we assume  $k_d > k_l$ .

### 3.1.2. Payment systems

Domestic agents can use two alternative payment systems. The traditional payment system (cash, denoted C) is subject to payment of a *per transaction* cost (denoted  $t$ ,  $0 < t < 1$ ).

When receiving a remittance  $r_i$ , domestic agents using cash obtain  $r_i(1-t)$  from this remittance. Using cash provides access only to local exchanges. Thus, domestic agents that receive  $r_i$ , derive utility  $u_{C,i}$  from use of cash:

$$u_{C,i} = k_l r_i (1-t) \quad (1)$$

The mobile payment system (denoted M) is proposed by a mobile operator. In accordance with the practices common to many countries, this operator supplies the payment system with a flat rate subscription scheme  $p$ <sup>9</sup>

8 For the sake of simplicity, and as remittances mainly concern low revenue receivers, we exclude the possibility of distant B2C payments online using or mobile technologies via Paypal or equivalent payment services.

9 This is for instance the pricing model actually used in Tanzania, (see e.g. Jang and Park 2016). Other countries often associate an entry cost (in our model, qualitatively similar to a flat rate in our model) and some proportional fees. If there is a positive

Hence, domestic agents receiving  $r_i$  and using the M-payment system eventually obtain  $(r_i - p)$ .

Using the mobile payment system provides access to both distant and local consumption opportunities while cash provides access only to local consumption opportunities through local exchanges. Thus, when using the M-payment system, domestic agents obtain the utility level in Equation 2:

$$u_{M,i} = (r_i - p) \left( k_d \left( \frac{m^e}{n} \right) + k_l (1 - t) \left( 1 - \frac{m^e}{n} \right) \right) \quad (2)$$

In equation (2),  $m^e$  is the expected number of domestic agents using M-payment and  $m^e/n$  is the overall adoption rate of M-payment among the whole population of domestic agents. The first term captures the utility derived from distant exchanges. Consider a person-to-person exchanges. Each of these distant exchanges provides utility  $k_d$ . However, implementation of an exchange is conditional on other trader adopting the M-payment service. We account for that by considering that implementation of a distant exchange depends on the expected M-payment adoption rate  $\left(\frac{m^e}{n}\right)$ . This generates a network externality for M-payment use which we assume to be linear. This externality does not apply to cash since by definition, all agents accept cash. Other exchanges  $\left(1 - \left(\frac{m^e}{n}\right)\right)$  are implemented locally and each provides utility  $k_l$ . Last, because of the flat rate nature of the transaction cost incurred when using M-Payment, the available purchasing power is given by  $(r_i - p)$  as M-payment is used, even for a small proportion of transactions. This explains that the whole parenthesis is multiplied by  $(r_i - p)$  in equation (2).

At step 2, domestic agents  $i$  need to choose among exclusive use of cash (C) or mixed use of M-payment (M) and cash in order to maximize utility and obtain  $u_i^* = \max\{u_{M,i}, u_{C,i}\}$ . To differentiate from those agents that only use cash, we denote those agents that use cash and M-payment as *M-payment users* by convenience. However, in accordance with actual payment systems, recall that those users always use both payment exchange systems since M-payment cannot substitute for all possible transactions.

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fixed fee and if the proportional fee is sufficiently low, introducing a proportional fee would not change the results qualitatively. Thus, we do not integrate these costs explicitly.

### 3.2. Step 1 (migrant agents) : remittance decision

Migrant agents  $i$ , ( $i = 1, \dots, n$ ) are endowed with a revenue  $w_i$  derived from their own production activities (e.g., wages). Because these activities potentially originate from various countries and various sectors, it is essential to consider some heterogeneity among migrant agents. This revenue is used for distribution to the domestic household  $r_i$  and for personal consumption  $c_i$ . The preferences of the migrant agent  $i$  can be depicted by an indirect utility function which includes both a personal and an “altruistic” components. We consider the simplest form of this function in equation (3).

$$U_i = \max \{u_{M,i}, u_{C,i}\} (w_i - r_i)^\alpha \quad (3)$$

The first term depicts the utility from distribution to the domestic household. The second term depicts the utility from the migrant agents’ own consumption. Thus, parameter  $\alpha$  ( $\alpha > 0$ ) is an inverse measure of the migrant agents’ propensity for altruism.

At step 1, the objective of the migrant agent is to maximize (3) with respect to  $r_i$ . To do this, we make two technical assumptions. First, we assume perfect fit between the preferences of the domestic agents and those of the migrant agent i.e., there is no difference between the perceptions of the utility of domestic agents by migrant agents (equation (3)) and the domestic agents’ actual utility (equations (1) and (2)). Second, we consider an equilibrium with perfect expectations in the sense that the actual number of receivers adopting m-payment is equal to the expected number ( $m^e = m^*$ ).<sup>10</sup>

### 3.3. Benchmark

To analyze the economic impacts of the introduction of M-payment, we define the benchmark as the situation prior to its introduction. Thus, in

<sup>10</sup> This assumption is quite reasonable since we focus here on long term outcomes. However, actual adoption rates during the adoption process of M-payment is not always public knowledge. Analysis of medium-run outcomes would require a specific dynamical setting.

the benchmark case, domestic agents can only use cash and are restricted to local exchanges.

**Lemma 1.** *At step 2 of the benchmark case, all domestic agents use cash and  $m^* = 0$ . At Step 1 of the benchmark case, the equilibrium individual remittance is  $r_{i,B}^* = w_i / (1 + \alpha)$  and total equilibrium remittance flows amount to  $R_B^* = \frac{n(\bar{w}-w)(\bar{w}+w)}{2(1+\alpha)}$ .*

*Proof.* See Appendix ■

As stated in Lemma 1, an increase in  $w_i$  influences the level of individual remittance positively. This is true also at the aggregate level: an increase in the upper bound of the revenue distribution ( $\bar{w}$ ) influences total remittances positively. Note however, that an increase in the cost of using the cash system ( $t$ ) has no direct impact on individual (and thus total) remittances but has a negative impact on domestic and migrant agents' surpluses. Finally, note that an increase in  $\alpha$  (i.e. less altruistic migrant agents) has a negative impact on the individual and aggregate levels of remittances.

From the equilibrium remittance values, we deduce the aggregate surplus of domestic and migrant agents.

**Lemma 2.** *In the benchmark case, the equilibrium surplus of domestic agents (DoS) amounts to  $DoS_b^* = \frac{k_j n(1-t)(\bar{w}-w)(\bar{w}+w)}{2(1+\alpha)^2}$ . The equilibrium surplus of migrant agents (MiS) amounts to  $MiS_b^* = \frac{k_j n(1-t) \left( \frac{-2(\bar{w}\alpha)}{w(1+\alpha)} - w^2 \left( \frac{w\alpha}{1+\alpha} \right)^\alpha \right)}{(1+\alpha)(2+\alpha)}$ . Total equilibrium welfare amounts to  $W_b^* = DoS_b^* + MiS_b^*$ .*

*Proof.* See Appendix ■

Then these values are compared to those in the equilibrium with M-payment.

## 4. RESULTS

Section 4.1 characterizes the equilibrium outcome with M-payment adoption and uses comparative statics to analyze the impact of key parameters.

Section 4.2 compares the two equilibrium outcomes to derive the impact of M-payment introduction on aggregate economic variables.

## 4.1. Equilibrium outcome with M-payment

We focus here on interior outcomes *i.e.*, outcomes where some domestic agents use only cash and others make use of M-payment. A sufficient condition for this type of outcome to occur is that the price of access to M-payment services is not too high ( $p < \hat{p}$ ).<sup>11</sup> By convenience, we drop the ‘M’ subscript defining the equilibrium values at equilibrium with M-payment.

**Lemma 3.** *In the equilibrium with M-payment, domestic agents that receive  $r_{i,c}^* < \tilde{r}$  use cash only (see definition of  $\tilde{r}$  in Appendix). Those that receive  $r_{i,m}^* > \tilde{r}$  use M-payment. The individual remittance sent to cash users amounts to  $r_{i,c}^* = w_i / (1 + \alpha)$ . The individual remittance sent to M-payment users amounts to  $r_{i,m}^* = \frac{w_i + p\alpha}{1 + \alpha}$ .*

*Proof.* See Appendix ■

Lemma 3 defines the minimal individual remittance level ( $\tilde{r}$ ) required for the domestic agents to adopt M-payment at step 2 at equilibrium. From this definition, we can compute the equilibrium with M-payment and derive the following propositions.

**Proposition 1.** *In the equilibrium with M-payment, the proportion of M-payment services users is  $m^* / n = (\bar{r} - \tilde{r}) / (\bar{w} - \underline{w})$ . The number of M-payment users increases with  $t$  and  $k_d$  and decreases with  $p$  and  $k_l$ .*

*Proof.* See Appendix ■

As stated in Lemma 3, the domestic agents that use cash only are those that receive lower amounts of remittances. For those agents, the level of remittances sent is the same as that in the benchmark case. Those domestic agents that receive higher levels of remittances use M-payment. In doing so, these agents receive a higher individual remittance at equilibrium ( $r_{i,m}^* > r_{i,c}^*$ ).

<sup>11</sup> See Appendix for the definition of  $\hat{p}$ .

Simple comparative statics provide insights on the impact of the cost of using cash  $t$ : as previously, an increase in  $t$  has no direct impact on the remittance sent to cash users. However, this increase generates some substitution effects: as stated in Proposition 1, because of this increase, some agents switch to use of M-payment. While the level of remittances received when using M-payment is independent of  $t$ , those agents that switch to M-payment benefit indirectly from this increase in  $t$  because they receive a higher amount of remittances (since  $r_{i,m}^* > r_{i,c}^*$ ).

The effects of the price of the M-payment service  $p$  provide some interesting results. On the one hand, an increase in  $p$  is found to deter some domestic agents from using M-payment (proposition 1). This can be interpreted as a classical substitution effect since it is similar to an increase in the relative cost of M-payment vs. cash. However, the same increase in  $p$  generates a “compensation” effect at step 1 since for those domestic agents who continue using M-payment, an increase in  $p$  generates a higher level of individual remittance sent by migrant agents (proposition 1). This effect is based on the combination of the flat rate nature of the price access to M-payment and of the altruism of migrant agents towards domestic ones. Note however, that as  $p$  increases this compensation effect applies to a decreasing number of domestic agents.

**Proposition 2.** *In the equilibrium with M-payment, aggregate equilibrium remittance flows received by cash users  $R_c^*$  decrease with  $t$  and  $k_d$  and increase with  $p$  and  $k_l$ . The aggregate remittance flows received by M-payment users  $R_m^*$  increase with  $t$  and  $k_d$  and decrease with  $k_l$ . The effect of  $p$  on  $R_m^*$  is ambiguous. Total remittance flows amounts to  $R^* = R_c^* + R_m^*$ . It increases with  $t$  and  $k_d$  and decreases with  $k_l$ .*

*Proof.* See Appendix ■

The effects of  $p$  and  $t$  on the individual remittance have an impact also on aggregate remittances as shown by Proposition 2. An increase in the cost of using cash generates unambiguous impacts: this increase has a negative impact on those domestic agents that only use cash because they benefit from identical levels of individual remittances but both the number of cash users and the utility of cash users decrease. However, as  $t$  increases, M-payment users benefit from identical levels of individual remittances while the number of such users increases. Also, given the higher network externality generated by more numerous M-payment users, the utility

level of these users also increases. This change in the distribution of cash vs. M-payment users increases remittances as  $t$  increases, since use of remittances now becomes more “efficient”.

The price of M-payment services generates more ambiguous impacts. Similar to the reasoning above, although an increase in  $p$  has no impact on the individual remittances sent to cash users, it generates an increase in the number of cash users. This generates in turn an increase in the total remittance flows received by cash users. In the case of M-payment users, an increase in  $p$  has ambiguous effects on the total remittance flows received by M-payment: on the one hand, it decreases the number of M-payment users; on the other hand, it increases the level of the individual remittances sent to these users. The overall effect of these two effects combined is ambiguous. Specifically, the aggregate effect depends on a complex set of parameters (namely  $k_i, k_d, t$  and  $\alpha$ ) among which it is difficult to identify the role played by certain factors. Since aggregate remittance flows are composed of two flows as described above, the same ambiguity arises when considering the impact of the price of M-payment services on total remittance flows.

**Proposition 3.** *In the equilibrium with M-payment, the aggregate surplus of cash users increases with  $p$  and  $k_i$  and decreases with  $t$  and  $k_d$ . The aggregate surplus of M-payment users increases with  $k_d$ .*

*Proof.* See Appendix ■

In the case of propositions 1 and 2, the impacts of  $p$  and  $t$  on the aggregate surplus of cash users are mostly as expected: since a higher  $t$  (or lower  $p$ ) deters some domestic agents from using cash, and since those agents benefit from higher individual remittances, the aggregate surplus of cash users decreases. However, the effect of other variables ( $p$ ,  $k_i$  and  $t$ ) on the aggregate surplus of M-payment user is ambiguous. Consider an increase in  $p$ : as previously stated, this has two opposite effect (lower adoption rate of M-payment, higher individual remittances). So, the overall effect cannot be determined.

## 4.2. Effects of M-payment introduction

To formally evaluate the macro-impact of the introduction of M-payment, propositions 4 and 5 refer to comparison of the equilibrium macroeconomic

variables in the benchmark case (i.e., prior to M-payment introduction) as stated in lemmas 1 and 2, to the macroeconomic variables defined in the case with M-payment (propositions 1 to 3).

**Proposition 4.** *The level of aggregate remittances in the equilibrium with M-payment is always higher than that in the equilibrium with no M-payment (benchmark).*

*Proof.* See Appendix ■

Proposition 4 highlights the macroeconomic positive effect of using M-payment for internal exchanges on remittance flows. For a developing country, this provides some rationale for promoting use of M-payment in order to attract larger amounts of remittances. Note however, that other effects might prevail at the micro- and macro-economic levels. One of these can be described as a “crowding out effect”: because use of M-payment generates new and more favorable consumption opportunities for domestic agents, remitters could decide to decrease remittances once M-payment is introduced. This effect is not generated in our model and it is interesting to stress that this is independent of the level of altruism of migrant agents (measured inversely by  $\alpha$ ). Second, note that the result of Proposition 4 holds for non-use of M-payment services for the transfer of remittances from emitters to receivers (“remittance channel”). As previously stated, in some countries, M-payment services can be used also for transferring cash across countries (i.e. as a remittance channel). It might be expected from that the general results raised by Propositions 4 would be reinforced by the introduction of M-payment as an international transfer service. However, to confirm this would require precise knowledge about the implementation of an international transfer service (e.g., price scheme, compatibility/incompatibility with the internal service).

**Proposition 5.** *The level of surplus of domestic agents (resp. level of welfare i.e. surplus of domestic and of migrant agents) in the equilibrium with M-payment is always higher than the level of surplus of domestic agents (resp. welfare) in the equilibrium with no M-payment (benchmark).*

*Proof.* See Appendix ■

According to proposition 5, the surplus of domestic agents always increases with the introduction of M-payment. There are two explanations for

this result. First, M-payments enable exchanges that generate higher utility. Then, with identical remittance levels, those agents that adopt M-payments benefit from a higher level of surplus. However, crowding out effects might produce the opposite result. Proposition 4 predicts that individual remittances levels are always higher after the introduction of M-payment ; we do not observe any crowding out effects here, meaning that the two effects are reinforcing. In turn, this supports proposition 4 on the benefits to a developing country in promoting the diffusion of M-payment services. This holds also for 'welfare' defined as the sum of the surplus of domestic and migrant agents. However, note that this is a domestic and not a global measure of welfare since it does not account for losses in terms of revenue/consumption incurred by the host country of the migrant agents when those agents increase their remittance flows.

An obvious corollary of propositions 4 and 5 is that the introduction of M-payment alters the "geography of trade" in the domestic country by increasing trade between distant areas relative to trade within a given area. In our model, this result is induced by the fact that cash can be used only for local trades while M-payment is ubiquitous.

However, it is clear that some developing countries have developed other means to exchange money across two distant areas (e.g., through a fragmented banking system, or networks of physical intermediaries) so there are other channels allowing for distant trading. In this case, our model provides a rough simplification of actual practices; the introduction of such alternative would not qualitatively change the results though since a widespread use of M-payment would stimulate trade across areas because of the ubiquitous nature of M-payment.

## 5. CONCLUSION

The model provides other interesting findings on the role played by the price of the M-payment service and the cost of using cash. A decrease in the cash cost-of-use (caused by e.g., public investments in physical security, and in the road or financial infrastructures) might increase the use of cash and deter use of M-payment. However, the overall effect on aggregate remittances would be negative. In addition, the effect of a decrease in the price of M-payment services cannot be determined unambiguously.

While intuitively we would suggest that such a decrease would be positive for the economy, our model shows that this effect is not easily predictable since it induces more domestic agents to switch to M-payment use while at the same time, lowering the level of individual remittances sent by migrant agents.

Our framework is designed to apply to consumption decisions. To what extent the model can be applied to remittances for production motives remains an open question whose resolution would require deeper knowledge about the motives for sending remittances for other purposes such as e.g. investment, and the possible uses of remittances for these purposes. Also, this paper focused on the adoption of M-payment services for internal uses. Anecdotal evidence suggests that diffusion of M-payment services might be clustered geographically and this effect could be enhanced by cross-border operators, or by interoperability strategies adopted by operators in neighbor countries. This suggests that M-payment services could be used by remitters/receivers of remittances for international trades (Della Peruta, 2015). There is a need for a more complete empirical identification of these practices, and if they are confirmed, a precise analysis of their economic implications. This points to directions for future research.

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## APPENDIX

### Benchmark equilibrium: proofs of lemmas 1 and 2

#### *Proof of lemma 1*

Consider first the case of a domestic agent  $i$ . In the benchmark equilibrium, only use of cash is possible and agent  $i$  obtains the utility level defined by equation (1). Since  $u_{C,i} > 0$  for all possible parameter sets, the participation constraint of domestic agents for step 2 is always fulfilled, and in the benchmark equilibrium, all agents receive utility  $u_i = u_{C,i} = k_i r_i (1-t)$ . At step 1, knowing that domestic agents only use cash, migrant agents maximize  $U_i = u_{C,i} (w_i - r_i)^\alpha$  w.r.t.  $r_i$  for any  $w_i \in (\underline{w}, \bar{w})$ . From FOC, we derive that  $r_i^* = w_i / (1 + \alpha) \equiv r_{i,c}^*$ . It can be easily checked that since  $\alpha > 0$ , this optimum is always interior (i.e.,  $\underline{w} < r_i^* < \bar{w}$ ) and SOC are always filled. That proves Lemma 1.

#### *Proof of lemma 2*

Since optimal remittance  $r_{i,c}^*$  is a strictly increasing function of  $w_i$ , this defines the remittance distribution as a uniform distribution over the interval  $(\underline{r}, \bar{r}) \equiv (\underline{w} / (1 + \alpha), \bar{w} / (1 + \alpha))$ . Aggregate remittance flows in the benchmark equilibrium are defined as  $R_b^* = n \int_{\underline{w}}^{\bar{w}} r_i^* dw_i = \frac{n(\bar{w} - \underline{w})(\bar{w} + \underline{w})}{2(1 + \alpha)}$ . The domestic agents' surplus at the benchmark equilibrium ( $DOS_b^*$ ) amounts to  $DOS_b^* = n \int_{\underline{r}}^{\bar{r}} u(r_i^*) dr_i = \frac{k_i n (1-t) (\bar{w} - \underline{w})(\bar{w} + \underline{w})}{2(1 + \alpha)^2}$ . The migrant agents' surplus at the benchmark equilibrium ( $MiS_b^*$ ) amounts to  $MiS_b^* = n \int_{\underline{w}}^{\bar{w}} U(r_i^*) dw_i = \frac{k_i n (1-t) \left( \bar{w}^2 \left( \frac{\bar{w}\alpha}{1+\alpha} \right)^\alpha - \underline{w}^2 \left( \frac{\underline{w}\alpha}{1+\alpha} \right)^\alpha \right)}{(1+\alpha)(2+\alpha)}$ . The total surplus at the benchmark equilibrium amounts to  $W_b^* = DOS_b^* + MiS_b^*$ . That proves Lemma 2.

### Equilibrium outcome with M-payment: proofs of lemma 3, propositions 1, 2, and 3

#### *Proof of lemma 3*

Consider an equilibrium outcome with uses of both M and C at step 2. Consider first the case of domestic agents  $i$  at step 2. Those agents have

to decide between use of C or M in order to maximize their indirect utility. Comparing (2) and (1), it can be observed that the domestic agents that will use C are characterized by the lower levels of individual remittances. Thus, the decision about M vs. C depends on the individual remittance  $r_i$  received at step 1. If  $\tilde{r}$  is the minimal remittance level for M-payment use,  $\tilde{r}$  corresponds to the remittances of a domestic agent indifferent at step 2 about use of C or use of M.  $\tilde{r}$  is such that if the domestic agent  $i$  receives  $\tilde{r}$ ,  $u_{C,i} = u_{M,i}$ . For those domestic users that choose cash at step 2, optimal remittance decision  $r_{i,c}^*$  at Step 1 is the same as that in the benchmark case (i.e.,  $r_{i,c}^* = w_i / (1 + \alpha)$ , by derivation of  $U_i = u_{C,i}(w_i - r_i)^\alpha$  w.r.t.  $r_i$ ). For those domestic users that choose M at step 2, the migrant agents need to maximize  $U_i = u_{M,i}(w_i - r_i)^\alpha$  according to equation (3) w.r.t.  $r_i$ . From FOC, we can deduce the optimal level of remittances  $r_{i,m}^* = (w_i + p\alpha) / (1 + \alpha)$  sent by migrants agents to domestic agents that use M. Note that the condition for an interior outcome solution is that  $0 < r_{i,m}^* < w_i$ . The positivity condition is always fulfilled, and  $r_{i,m}^* < w_i$  is equivalent to  $p < w_i$ . Computation of SOC comes to the same condition  $p < w_i$ . Hence, it is necessary for the price of M-payment to be small enough for this interior outcome to occur. Assuming that  $p < w$  this is sufficient for all user potentially to adopt M-payment. A less strong assumption would be that only those agents that actually use M-payment fulfill this condition. This must be true for the domestic agents that adopt M-payment and receive the lowest individual remittance ( $\tilde{r}$ ). These domestic agents correspond migrant agents endowed with  $\tilde{w}$  (see below for the definition of  $\tilde{r}$  at equilibrium). Hence, we need to check  $p < \tilde{w} \equiv \hat{p}$  with  $\hat{p} = \frac{1}{2} \left( \frac{-2k_d \bar{w}(-1+\alpha) + k_l(-1+t)(\bar{w} + \underline{w} - 3\bar{w}\alpha + \underline{w}\alpha)}{(-2k_d + k_l(-1+t)(-1+\alpha))\alpha} + \sqrt{1(( -2k_d + k_l(-1+t)(-1+\alpha))^2 \alpha^2)} \right) (1 + \alpha)(4k_d^2 \bar{w}^2(1 + \alpha) + 4k_d k_l(-1+t)\bar{w}(\bar{w} + \underline{w} + \bar{w}\alpha - \underline{w}\alpha) + k_l^2(-1+t)((\bar{w} + \underline{w})^2 + (\bar{w}^2 - 6\bar{w}\underline{w} + \underline{w}^2)\alpha))$ .

Inside the range of definition, individual optimal remittance levels  $r_{i,m}^*$  and  $r_{i,c}^*$  are both increasing functions of  $w_i$ . So lower (resp. higher) income levels are associated with lower (resp. higher) remittance levels allowing use of C (resp. M). From that, we can deduce the lower ( $\underline{r}$ ) and upper ( $\bar{r}$ ) bounds of the remittance distribution at an equilibrium with M-payment:  $\underline{r} = \underline{w} / (1 + \alpha)$  and  $\bar{r} = (\bar{w} + p\alpha) / (1 + \alpha)$ .

For an outcome with both M and C occurring at step 2, we thus need  $\underline{r} < \tilde{r} < \bar{r}$ . By definition, the mass of M-payment users amounts to  $\tilde{m} = n \left( \frac{\bar{r} - \underline{r}}{\bar{r} - \underline{r}} \right)$  and we

can replace  $\underline{r}$  and  $\bar{r}$  by their values hence  $\tilde{m} = n(\tilde{r}(1 + \alpha)) / (\bar{w} + p\alpha - \underline{w})$ . In an equilibrium with perfect expectations, agents refer to this value of  $\tilde{m}$  to estimate the mass of M-payment adopters at Step 2 and this value is used to assess the utility from M in equation (2). From that, we derive the marginal agents by solving  $u_{C,i} = u_{M,i}$  with respect to  $\tilde{r}$ . There are two potential roots ( $\tilde{r}_1$  and  $\tilde{r}_2$ ) and one of which satisfies the condition  $\underline{r} < \tilde{r} < \bar{r}$ . Thus there is a unique equilibrium characterized by

$$\tilde{r}_1 = \frac{\left( (k_d + k_l(-1+t))(p-\bar{w}) + \sqrt{\left( (k_d + k_l(-1+t))\left( k_d(p+\bar{w}+2p\alpha)^2 + k_l(-1+t)\left( p^2 + \bar{w}^2 + p(-2\bar{w}+4\underline{w}(1+\alpha)) \right) \right) \right)} \right)}{(2(k_d + k_l(-1+t))(1+\alpha))} \equiv \tilde{r}^*.$$

This proves lemma 3.

### Proof of proposition 1

Equilibrium values with M-payment are derived by replacing  $\tilde{r}^*$  into the M-payment adoption rate, the aggregate remittance levels, and the aggregate surplus levels. The effects of  $t$ ,  $p$ ,  $k_l$  and  $k_m$  are obtained by simple derivation of optimal equilibrium values. That proves Proposition 1.

### Proof of proposition 2

The equilibrium M-payment adoption rate  $\tilde{m}^*$  amounts to  $n\left(\frac{\bar{r}-\tilde{r}^*}{\tilde{r}^*-\underline{r}}\right)$ . The aggregate level of remittances sent to M-payment users amounts to  $R_m^* = n \int_{\bar{w}}^{\underline{w}} r_i^* dw_i$ . The aggregate level of remittances sent to cash users amounts to  $R_c^* = n \int_{\underline{w}}^{\bar{w}} r_i^* dw_i$ . The aggregate remittances amount to  $R^* = R_c^* + R_m^*$ . The effect of parameters  $t$ ,  $k_d$ , and  $k_l$  on  $R_c^*$ ,  $R_m^*$  and  $R_c^* + R_m^*$  can be deduced from comparative statics analysis on these three expressions. That proves Proposition 2.

### Proof of proposition 3

The aggregate level of the surplus of domestic users using M-payment amounts to  $DOS_m^* = n \int_{\underline{r}}^{\bar{r}} u(r_i^*) dr_i$ . The aggregate level of surplus of migrant agents associated with domestic agents using M-payment amounts to  $MiS_m^* = n \int_{\underline{w}}^{\bar{w}} U(r_i^*) dw_i$ .

The aggregate surplus amounts to  $W_m^* = DOS_m^* + MiS_m^*$ . The effect of parameters  $t$ ,  $k_d$ , and  $k_l$  on  $R_c^*$ ,  $R_m^*$  and  $R_c^* + R_m^*$  can be deduced from

comparative statics analysis on these three expressions. This proves proposition 3.

## **M-Payment equilibrium/Benchmark comparison: proofs of propositions 4 and 5**

### *Proof of proposition 4*

In the equilibrium with M-payment, domestic agents using cash receive the same individual amounts of remittances ( $r_{iB}^*$ ) as those received in the benchmark equilibrium (see lemma 2). M-payment users receive an amount of individual remittance equal to  $r_{im}^*$  as defined by lemma 3 rather than  $r_{iB}^*$  in the benchmark. As for all positive value of  $p$ ,  $r_{im}^* > r_{iB}^*$ , individual remittance levels increase with the introduction of M-payment for M-payment users. Thus, the aggregate level of the remittances received increases. That proves Proposition 4.

### *5.2.1. Proof of proposition 5*

Because individual remittances are unchanged, the utility of the domestic agents using cash in the equilibrium with M-payments is unchanged compared to the benchmark equilibrium. Domestic agents using M-payments at the M-payment equilibrium prefer this to using cash only, so their level of utility increases with the introduction of M-payments. Then, at the global level, aggregate utility is larger in the equilibrium with M payments compared to the benchmark equilibrium.

Now let us compare the utility of migrant agents in the benchmark and the M-payments equilibria. Those migrant agents that send remittances to cash users provide the same level of individual remittances and also have the same level of utility. Consider the case of domestic agents that send remittances to M-payment users. Given the optimal levels of individual remittances in the two cases, once M-payment is introduced, the domestic agent will continue to consider cash payment as the more suitable solution based on its own utility, and the migrant agent will provide remittances equal to  $r_{i,B}^*$  and not  $r_{i,M}^*$ . Consequently, the utility level of these agents remains unchanged, and the utility of the associated domestic agents does not decrease. When  $i$  continues to increase, the situations remains

the same until  $i^{**}$  such that  $U_{i^{**}} = u_{M,i^{**}}(w_i^{**} - r_{i,m}^{**})^\alpha = u_{C,i^{**}}(w_i^{**} - r_{i,B}^{**})^\alpha$ . From  $i^{**}$  and for values of  $i$  greater than  $i^{**}$ , the remittances sent by migrant agents increases to  $r_{i,m}^*$  which increases the migrant agents' level of utility. As the net utility of corresponding domestic agents also increases, the utility of the migrant agents increases for all values of  $i$  from  $i^{**}$ . Then the aggregate utility of households also increases. That proves Proposition 5.