The Home Economics of E-Money: Velocity, Cash Management, and Discount Rates of M-Pesa Users[†]

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M-Pesa, a service operated by the mobile phone network Safaricom in Kenya, allows users to deposit money onto their telephone handsets, transfer e-money to another user with a simple text message, and withdraw cash at one of thousands of outlets throughout the country. The system is safer, cheaper, and far faster than the money transfer systems that it replaced. Although only five years old, M-Pesa has achieved remarkable penetration into the Kenyan economy. As of September 2011, there were 32,000 M-Pesa outlets at which individuals could exchange cash for e-money or vice-versa, in a country that as of 2009 had 491 bank branches, 500 postbank branches, and 352 ATMs (Mas and Ng'weno 2009). In the six-month period April–September 2011, the volume of transfers was Ksh 314 billion, compared to nominal GDP of Ksh 2.99 trillion that year. (For the period from which our data are drawn, the market exchange rate was approximately 75 Ksh/dollar, and the PPP exchange rate was approximately 35 Ksh/dollar).

At present, M-Pesa is primarily a money transfer system. However, it has the potential to evolve in two exciting directions: first as a gateway via which unbanked households can access financial services, and second, as a transaction medium, with e-money partially replacing cash.[1]

Even in its current form, however, M-Pesa represents a dramatic change in the economic environment of Kenyan households. Further, data on how households use M-Pesa allows for insight into the objectives of and constraints on their money management choices, and consumption more generally.

I. Monetary Characteristics of E-Money

A. *Velocity*

For the purposes of understanding where M-Pesa fits into a broader monetary framework, we are interested in calculating the "velocity" of M-Pesa. In standard monetary economics, there are two different definitions of velocity that are used. "Income velocity" is nominal GDP divided by the relevant money stock. "Transactions velocity" is defined as the frequency with which the average unit of money is used in transactions. Although in some ways more fundamental than income velocity, transactions velocity is much harder to measure, because doing so requires being able to observe actual transactions.

In the case of M-Pesa, the potentially relevant transactions are the creation of a unit of e-money (corresponding to a deposit of cash with an M-Pesa agent), transfer of e-money from one user to another, and withdrawal of cash (extinguishing of a unit of M-Pesa). Further, among transfers that take place, some will be in the nature of payments (for example, a user transfers e-money from her account to that of a merchant in return for goods and services), while others will be in the form of a gift (for example, one family member sending money to another). The majority of transfers observed are of the latter type, although this has been changing as the system matures.

As our measure of M-Pesa velocity, we focus only on transfers. Our measure is thus the total value of person-to-person transfers (i.e.,

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[1] As discussed in Mbiti and Weil (2011), Safaricom introduced a savings product, M-Kesho, as well as an insurance product, both of which are linked to the M-Pesa account. Safaricom recently (in December 2012) announced the launch of a new service, M-Shwari, that is essentially an improved version of M-Kesho offering customers a way to earn interest on balances and also obtain small loans through its partner commercial bank.

transfers in which neither party is an M-Pesa agent) per unit time divided by the average outstanding balance of e-money. We call this "transfer velocity."

Of the two numbers required to measure transfer velocity, the harder one to obtain is the outstanding balance of e-money. All money deposited to create e-money is held by a trust fund which holds deposits in commercial banks. Thus, the outstanding balance of e-money is in principle perfectly observable at any point in time, although the information is not normally made public. Weil, Mbiti, and Mwega (2011) use data on the size of the trust balance monthly from July 2007 through December 2011.

While the trust balance is by construction identical to the quantity of e-money outstanding, to calculate transfer velocity, we want to adjust for e-money that is held by M-Pesa agents. We construct an estimate of this quantity by subtracting estimated e-money held on the phones of M-Pesa agents from the trust balance. Eijkman, Kendall, and Mas (2010) report end of day e-money for different types of M-Pesa outlets. These range from Ksh 90,000 for rural stores to Ksh 40,000 for city stores. Rural stores have particularly high end of day float because they do a primarily cash-out business, that is, they primarily pay out cash in return for e-money presented by their customers. City stores did a more balanced business, though with an excess of cash-in over cash-out. In our calculations we chose a value of Ksh 50,000 per M-Pesa agent. Multiplying this by the number of M-Pesa agents gives our estimate of total e-money held by M-Pesa agents. From the Safaricom website, we have data on the number of agents monthly from April 2007 through April of 2011. For most of the existence of M-Pesa, the ratio of e-money held on agent phones to total e-money has fluctuated narrowly within the range of 10–12 percent.

The other piece of information required for the calculation of transfer velocity is the monthly value of person to person transfers. This is reported by Safaricom for the period April 2007–April 2010. Using this data, Figure 1 shows our calculated value of monthly transfer velocity. The series shows a significant upward trend, rising from roughly two transfers per month in the first year of M-Pesa's operation to roughly four in the last few months for which we have data.
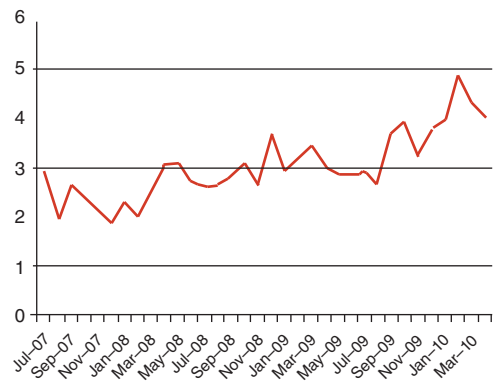

Figure 1. Transfer Velocity of M-Pesa

The calculated values of velocity seem to indicate that M-Pesa is functioning as a hybrid of a money transfer system, on the one hand, and a means for storing value, on the other. Velocity of four, for example, implies that the average unit of e-money was transferred once per week. If M-Pesa were purely being used as a money transfer system, we might expect that velocity would be significantly higher. For example, a simple deposit-transfer-withdraw transaction might involve e-money being created (in the sense that it is transferred from an agent to a customer), transferred, and extinguished (transferred back to an agent's phone) in much less than a day. This would imply a velocity of over 30 transfers per month. Since we know anecdotally that at least some users indeed do not keep e-money on their phones for very long, our estimates of velocity imply that some other users are keeping their cash on phones for significantly longer than one week. Such a situation would imply that most e-money at any point in time is held by nonfrequent transactors, even though most transfers are done by frequent transactors.

Velocity can be written as the ratio of monthly transfers per customer to average balances held per customer. Weil, Mbiti, and Mwega (2011) find that rising monthly transfers per customer were the major factor leading velocity to rise, although this series was quite stable around Ksh 2,700 after December 2008. Balances of e-money per customer were relatively stable, in the neighborhood of Ksh 800, although they fell by about 20 percent from July 2009 to April 2011.

One of the reasons that economists care about velocity is that it measures the degree to which different components of the money supply contribute to aggregate demand. Were it the case that e-money had a notably higher velocity than other types of money, then it would be possible that conventionally measured monetary aggregates were understating the effective money supply. For the present, however, this is not a concern, because M-Pesa is still very small. In December 2011, currency outside of banks (M0) was Ksh 137 billion, while currency plus demand deposits (M1) was Ksh 623 billion (Central Bank of Kenya 2011). By contrast, in that month, the balance of e-money outstanding was only Ksh 17.4 billion.

B. *The E-Money Loop*

Irving Fisher defined the "cash loop" as the number of transactions that a unit of currency goes through between being withdrawn from a bank and returning to a bank. Analogously, we can think of the "e-money loop" as the number of transfer transactions that the average unit of M-Pesa goes through between being transferred onto a customer phone and being transferred back from a customer phone to the phone of an M-Pesa agent.

As with velocity, we can put together available scraps of information to get an estimate of the length of the e-money loop; Kimenyi and Ndung'u (2009) give the value of "deposits plus withdrawals" for the period July 2007–July 2009. We combine this with data from Safaricom on the monthly value of person-to-person transfers. For a system that is not growing over time, the relationship between deposits, withdrawals, transfers, and the length of the e-money loop is[2]

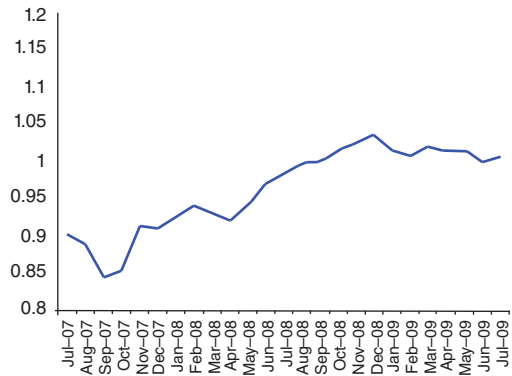$$looplength = \frac{2 \times transfers}{deposits + withdrawals}.$$

FIGURE 2. LENGTH OF THE E-MONEY LOOP

Figure 2 shows our calculated loop length. It is interesting to note that in the data the e-money loop starts out at slightly less than one before trending up to almost exactly one. A loop length of one would obtain if all transactions took the form of deposit-transfer-withdraw, while a length greater than one would be observed if some people who received a transfer sent e-money on somewhere else without doing a withdrawal. Similarly, loop length will be reduced to the extent that people use their phones to store money without its ever being transferred. Of course, it is possible that there was a good deal of both these activities (receiving money and transferring it onward without taking money out, on the one hand, and depositing and withdrawing without transferring, on the other), but the data are suggestive, at least to us, of the overwhelming majority of use being of the deposit-transfer-withdraw type.

Observation of the length of the e-money loop provides a convenient diagnostic about the extent to which e-money is substituting for cash (which has a long loop length) as a means of transactions. Clearly, in this data, little or no such substitution is taking place.

II. Household Cash Management

A. *Prices*

Table 1 shows a simplified version of the M-Pesa fee schedule (we ignore transfers to and withdrawals by nonregistered users, as these are

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[2] The key assumption required to derive this equation is that the system is in a steady state, where monthly deposits are equal to monthly withdrawals. In this case (deposits + withdrawals)/2 is just equal to the quantity of deposits. Also, in this case, transfers made in a given month would be equal to transfers that would eventually be made with the e-money created in a given month. The formula is not fully accurate, since M-Pesa was, in fact, growing over time.

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TABLE 1—M-PESA FEE SCHEDULE (KSH)

Transaction type	Range	Charge
Deposit cash	100–35,000	Free
Send money to registered user	100–35,000	30
Withdraw cash (registered user)	100–2,500	25
	2,501–5,000	45
	5,001–10,000	75
	10,001–20,000	145
	20,001–35,000	170

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TABLE 2—DISTRIBUTION OF WITHDRAWAL AMOUNTS (KSH)

	Cyber Center	Katito	Homa Bay
Observations	3,477	6,401	2,787
Mean	2,757	1,402	5,762
Tenth percentile	300	250	390
Twenty-fifth percentile	500	475	700
Median	1,000	900	1,970
Seventy-fifth percentile	2,850	1,680	6,500
Nintieth percentile	6,370	3,000	18,500

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relatively rare).[3] A notable characteristic of the schedule is the "price notches," in the sense of Slemrod (2010): points at which an incremental change in customer behavior causes a discrete jump in costs. The incentives at price notches are far stronger than those associated with kinks in price schedules such as changes in marginal tax rates. For example, the fee for withdrawing up to Ksh 2,500 is Ksh 25, while the fee for withdrawing Ksh 2,501–5,000 is Ksh 45. Thus, a person who withdraws Ksh 2,600 will be paying a marginal fee of Ksh 20 (20 percent) on the last Ksh 100 withdrawn compared to a fee of 1 percent on the first Ksh 2,500 withdrawn. Below we examine the behavioral response to these kinks.

B. *Transaction Frequency and Size*

Weil, Mbiti, and Mwega (2011) examine data on the frequency of M-Pesa use from the 2009 FinAccess Survey. Focusing their regression analysis on M-Pesa users, they show that urban users, highly educated users (secondary school graduates and above), and individuals with more assets used M-Pesa more frequently than their rural, less educated, and poorer counterparts. Their estimates show that, for instance, an urban M-Pesa user conducts six more transaction per annum relative to a nonurban user, while asset poor M-Pesa users conduct five fewer transactions per year relative to "non–asset poor" users.

The FinAccess Survey also contains information on frequency of M-Pesa use among individuals who describe themselves as users. For example, among men, 1.2 percent report using M-Pesa daily, 12.5 percent weekly, 32.4 percent monthly, and 53.9 percent irregularly. Mbiti and Weil calculate annual frequencies of use from these data. Some of their calculated values are men 21.4; women 15.7; banked individuals 27.8; nonbanked 10.4; rural 13.5; urban 23.9.

One implication from this data is that while many individuals do not use M-Pesa frequently, the average transaction (deposit, withdrawal, or transfer) is made by a frequent user. Mbiti and Weil calculate that daily users account for 32 percent of transactions, weekly users for 41 percent of transactions, monthly users 21 percent, and irregular users account for only 6 percent.[4]

Complementing this survey data, Mbiti and Weil also obtained data on withdrawals and deposits from three M-Pesa agents: Cyber Center, an urban outlet near one of the markets in the city of Kisumu; Katito, a small town with a population of roughly 5,000, located in a rural area; and Homa Bay, a provincial market town with a population of roughly 20,000 on a main highway (more information is given by Eijkman, Kendall, and Mas, 2010). Table 2 gives data on the distribution of withdrawals. The most striking finding in these data is the extent to which a

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[3] In March 2012, after the period from which our data are drawn, the price schedule was changed. Most notably, lower prices were introduced for very small transactions (Ksh 5 to transfer Ksh 100, and Ksh 10 to withdraw up to Ksh 100), and the fee for large transfers was increased (Ksh 50 for transfers of Ksh 5,000–20,000 and Ksh 75 for transfers above that up to Ksh 40,000).

[4] Aside from sending and receiving transfers, data from the 2009 FinAccess and Jack and Suri (2012) show that the main other uses reported by M-Pesa users were saving or storing money (sometimes even temporarily, such as when a user travels on a bus and wants to safely store his money), and/or were paying for goods and services. The proportion of users paying for services via M-Pesa grew from 3 percent in 2009 to over 30 percent in 2012.

large part of the distribution is composed of very small withdrawals.

Mbiti and Weil also present histograms showing the distribution of withdrawal amounts. They find that there is no concentration of withdrawals at amounts corresponding to price notches, other than the lumping one would expect at round-number amounts. For example, at all three outlets, withdrawals of Ksh 2,500 (just below a price notch) are much less common than withdrawals of either Ksh 2,000 or Ksh 3,000.

C. *Implied Discount Rates*

Our knowledge of how individuals manage their M-Pesa accounts is imperfect and circumstantial. Far better data are locked away in Safaricom's computers. Nonetheless, we can pull together several pieces of information to paint a suggestive picture. Specifically, we note that (i) most M-Pesa transactions are made by frequent users; (ii) there is little evidence of spikes in the density of withdrawals at points where there is a price notch; (iii) the average time that a unit of M-Pesa remains on a user phone is about one week. These observations suggest that the majority of users do not use their phones for storing value, and that the majority of transactions in the system involve one user depositing money to a phone and transferring it while a second user withdraws cash soon after receiving a transfer.[5]

These observations of behavior allow for insight into households' operative discount rates. Although M-Pesa balances do not pay explicit interest, holding money in M-Pesa does yield interest in the form of reducing transaction costs.

Consider a very simple model of a household that receives small, regular monthly transfers. One strategy would be to withdraw each transfer as it is received. An alternative would be to group two or more transfers together and withdraw them all at once (for simplicity in this example, the only alternative strategy we consider is grouping two transfers at a time together). The latter strategy holds money on the M-Pesa account for longer but involves lower costs.

Let W be the monthly transfer received, and C be the withdrawal cost (we assume that W is such that $2W$ can be withdrawn at the same cost as W). The monthly discount rate r at which an individual would be indifferent between these two strategies is given implicitly by the equation

$$W - C + \frac{W - C}{1 + r} = \frac{2W - C}{1 + r}.$$

Using values of $W = 1,000$ and $C = 25$, which would be consistent with the M-Pesa fee schedule and the data we have on the distribution of withdrawals, implies that a household that makes monthly withdrawals is discounting future cash flows at a rate of at least 2.6 percent per month (36 percent per year).

From these data it seems reasonable to conclude that a significant fraction of withdrawals are made by people who are applying high time discount rates, since otherwise they would be grouping their withdrawals into more economical chunks.

It is important to note that the high financial discount rates that households apply to cash that moves through M-Pesa do not necessarily imply that households highly discount the future consumption flows or utility. As in a standard Baumol-Tobin model of cash management, another reason to hold small cash balances is if there is a high cost of holding cash itself. Such a cost could be due to theft in a conventional sense, which can be viewed as a tax on cash balances. However, crime rates would have to be extremely high to justify the behavior we see. A more likely cost of holding cash is the high implicit tax represented by the ability of other family members to request either gifts or loans from one's available cash balances. This notion is supported by Ashraf (2009), who reports that women in Kenya often form secret saving societies to hide income from their husbands. Finally, and somewhat similarly, holdings of cash may simply raise temptations to spend that individuals find impossible to resist. The inability to save cash-holdings has been shown to be a constraint to fertilizer adoption in Western Kenya (Duflo, Kremer, and Robinson 2011) and promotes participation in ROSCAS which can act as a commitment saving device (Gugerty 2007). It could be that the extra transaction costs associated with

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[5] Our view that individuals do not use their phones for storing value runs counter to the result reported in Jack and Suri (2011) that three out of four M-Pesa users report using it to save money.

holding small cash balances are a price worth paying to avoid giving in to these temptations.

Another possibility is that individuals were just getting used to the pricing structure and would learn how to optimize their use of M-Pesa over time. Data from Jack and Suri (2012) show that in 2008, 56 percent of users who received an M-Pesa transfer withdrew the funds immediately, compared to just 21 percent in 2011.

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