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Compatibility and Interoperability in Mobile Phone-Based Banking Networks

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Abstract

In many developing countries of Africa and Asia, cell phones are used (i) to transfer money across individuals; (ii) to securely self-transport money, and (iii) to save/store money. These banking networks ride on top of wireless telecommunications networks. Traditionally each banking network was tied to the network of a telecom carrier and transfers were available only within the carrier's network, making it incompatible with banking networks of other carriers. In Tanzania, mobile banking under incompatibility was well established for a decade until September 2015 when the second, third, and fourth largest carriers established full compatibility of their banking networks. Analyzing a comprehensive dataset of banking transactions provided by a large telecom carrier in Tanzania, this paper discusses pricing under compatibility, contrasts with pricing under incompatibility. We analyze the transaction termination fees in this environment of practically no regulation, and assesses the individual and collective incentives for compatibility, noting that the largest carrier has remained incompatible. We find that carriers have agreed to very high prices for transfers across networks, and calculate the welfare gains under a number of counterfactual scenarios.

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1. Introduction

Network compatibility is a crucial issue in traditional networks such as in telecommunications, in modern networks such as the ATM banking networks, and in software setups of complementary goods. Although interconnection, full compatibility, and termination fees are imposed by regulation in voice telecommunications, termination fees in ATM networks are unregulated, and even the existence of compatibility is a commercial decision in software industries as well as in telecommunications hardware.

The theoretical literature on compatibility shows that networks of comparable sizes are more likely to want to be compatible, but larger networks prefer incompatibility in their connections with smaller networks.[1] When large size inequalities are present, even in the presence of compatibility, a large network may use large termination fees to marginalize smaller rival networks and even drive them out of business, as it occurred in the 1990s in New Zealand.[2] The experience of AT&T belligerently refusing to interconnect before the imposition of regulation in the 1930, and the possibility of strategic use of termination fees to marginalize rivals has prompted the US regulation imposing telecommunications termination fees at cost and close to zero.

Despite the plethora of theoretical academic work on compatibility, there is only limited empirical work on the issue. Empirical work on the transition from incompatibility to compatibility or vice versa is hampered by the fact there are only few cases where networks were observed making this transition. The mobile money transfer networks of Tanzania provide an interesting exception as they started as incompatible networks and they transitioned to compatibility. Additionally, Tigo, one of the networks, has provided us with transactions spanning the period of the transition.

Mobile money transfer networks are a key feature of banking in many developing countries and especially in Western Africa, and Tanzania, where we focus.[3] Each mobile banking network is set up by a mobile telephone company and traditionally functioned only for transfers between subscribers of the same network. The network works as follows. A subscriber deposits cash in his account with the telephone company (*cash-in*, at no charge) and can transfer it to another subscriber (including to a merchant to cover purchases) paying a *transfer fee*, or withdraw it paying a *cash-out fee*.

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[1] See Economides (1991).

[2] This is discussed in detail in Economides, Lopomo and Woroch (1996), (2009).

[3] Tanzania has approximately 58 cellphones per 100 residents. Source: knowcache.com.

The mobile banking networks of the four mobile networks in Tanzania functioned as incompatible networks for a number of years. They were incompatible in the sense that there was not a software-based automatic way to transfer money from a subscriber of network A to one of network B. Under incompatibility, money would need to be cashed out in network A and then cashed in a separate transaction in network B, and then transferred to the subscriber of network B.

On September 15, 2015, the three smaller mobile banking networks, Tigo Airtel and Zentel, with market shares 30%, 30% and 4%[4] respectively, decided to create a software based interface that would allow subscriber-initiated transfers across networks. The largest network, Vodacom (market share 35%), remained incompatible to the other three networks.

This paper discusses the fee structure that the networks adopted once they were compatible. We find that the networks adopted high fees and we calculate the extent of higher profits and higher consumers' surplus that would have been achieved if lower fees were adopted for across-networks transfers.

2. Data and Industry Background

The data set consists of all transactions in Tigo, the second largest mobile money operator in Tanzania. Transactions range from March 1st, 2014 to December 31st, 2015. The money is cashed-into the network using a network of agents, who are usually small business operators running grocery stores or specialized kiosks. The agent is paid a commission at cash-in, but cash-in is free to the customer. The data provide information about all cash-in transactions and agent commissions, the customer and agent IDs, and the account balance before and after the cash-in. We also observe cell phone tower ID of the customer and agent that allows us to provide an estimate of the GPS location of the location of the transaction.

Once on the mobile account, the money can be used in the variety of ways. Primarily, the money can be cashed-out, using the same agent network that facilitates the deposits. In addition to cashing out, the network allows to use the balance in a variety of ways. Table 1 details all possible transactions ordered by popularity. In this paper, we will concentrate our attention on the most popular transaction type, that is, a peer-to-peer transfer (P2P). In a P2P transfer, a customer can electronically send the money to another customer. These transactions have relatively small fees, and do not carry a marginal cost to the company since they do not involve the agent network that implements the cash-ins and cash-outs.

[4] Source: knowcache.com

Table 1: Frequency of service by type

Service type	Frequency
Cash-in	23%
Cell phone top up	21%
Cash-out	19%
P2P transfer	17%
Purchases	13%
Bill pay	5%
Other	2%

We observe the customer IDs of transaction counterparties, transaction size, account balances and the cell ID of the sender. We do not observe the cell ID of the receiver, since reception of P2P transfer is a passive operation that does not send or receive data from the receiver's cell phone. The location of the receiver can be estimated with a high degree of accuracy from other active transactions (such as account balance check).

Cash-outs carry significant fees detailed in Table 2 (fees for larger and less frequent transactions vary between 3500 and 7000 and are omitted from the table). Similarly to cash-ins, the data provides information about the IDs, account balance and tower ID.

Table 2: Cash-out fees

Amount	500-3999	4000-4999	5000-9999	10000-19999	20000-29999	30000-39999	40000-49999	50000-99999	100000-199999
Fee	500	600	750	1200	1350	1500	1750	2000	2500

Prior to September 15th, 2015 the only transfers allowed by Tigo terminated within Tigo's network, and similarly for all other networks. In other words, no network allowed its customers to send money to other networks' customers electronically. Instead, the customer had three options to make a transfer from Tigo to a customer of network B. First, the sender could cash-out the money from Tigo and hand cash to the receiver. Second, after cashing out from Tigo, the sender would cash-into network B and execute a transfer to the customer of B. Third, the sender in Tigo could ask for a voucher, that is, an equivalent of cashier's check that could then be redeemed in network B. The cash-out and voucher carry the same network fees and likely similar inconvenience costs. The only difference is that the voucher is more secure. After the introduction of compatibility, the out-of-network transaction can be executed electronically in a similar way the in-network transactions.

On July 5th, 2014, the network raised the prices of in-network P2P transfers. We use this natural experiment to estimate the price elasticity of demand. In our analysis, we use the one week before and after the price increase, and one week before and after introduction of compatibility. Fees of transfer services in the relevant time periods are given in Table 3. As shown in the table, the network raised prices of in-network transactions in the range 20,000-29,999 and 100,000-199,999 by between 16% to 25%. The remaining transfer brackets (up to 3,000,000 Shillings) have the same prices, before and after July 5th, are not displayed and are dropped from the analysis. Table 3 also notes the in-network and across-networks fees after September 15, 2015.

Table 3: Transfer fees

Transfer brackets	**20,000-29,999**	**30,000-49,999**	**40,000-99,999**	**49,000-99,000**	**100,000-199,999**
In-network transfer price one week before July 5th 2014	300	350	350	400	500
In-network transfer price one week after July 5th 2014	350	350	350	500	600
In-network transfer price one week before September 15th 2015	350	350	350	500	600
In-network transfer price one week after September 15th 2015	350	350	350	500	600
Out-network transfer price one week after September 15th 2015	1700	1850	2100	2500	3100

The second empirical fact evident from Table 3 is that across-networks transfers, feasible after September 15, 2015, are significantly more expensive than in-network transfers. This is driven by both the cost structure of the network as well as potentially by a different outside option when conducting a transfer to a person without a Tigo account. Regarding the cost, the networks pays its agents to facilitate cash-in and cash-out operations. However, the cash-in operation is provided free of charge to the user. Thus, the network subsidizes cash-ins and recoups its cost when the money is cashed-out (with a substantial fee) or when transferred multiple times within the network. When the money is transferred outside the network, the company does not collect the cash-out fee, nor does it collect further transfer fees. Thus, when conducting an out-of-network transfer, the cash-in cost is passed to the consumer through the across-networks transfer fee.

Interestingly, at the present compatibility status quo, the price of the out-of-network transfer is set equal to the price of the in-network transfer plus the cash-out fee. Thus, the network adopted the simplest possible pricing rule that is guaranteed to break even, as compared to the user cashing-out the money and using cash to make an out-of-network transfer. Moreover, an out-of-network transfer using Tigo is in fact more expensive than using cash, which reflects the inconvenience disutility of using cash.

As mentioned above, cash-ins and cash-outs have significant marginal costs. The cost to the network is presented in Table 4. On May 5th, 2015 and the network has lowered the agent commissions. The table presents the fees after the decrease that were in effect when the compatibility was introduced.

Table 4: Cash-in and cash-out commissions paid to agents (marginal cost)

Amount	1000-2999	3000-3999	4000-4999	5000-6999	7000-9999	10000-19999	19999-50000	50000-99999	100000-199999
Cash-in agent commission	45	70	100	125	150	225	275	350	600
Cash-out agent commission	200	200	200	200	200	200	300	400	600

3. The Model

We consider the following model of transfers. User ‘i’ receives the following utility from transferring ‘j’ amount of money:

$$u_{ij} = \alpha_j + \beta p_j + \varepsilon_{ij}$$

where p_j is the price of transfer of amount ‘j’. The amount of money transferred is discretized according to the transfer bins presented in Table 3. The utility of not transferring the money using Tigo is equal to $u_{i0} = \alpha_0 + \varepsilon_{i0}$. We allow for the outside option to vary across in-network and out-of-network transfers. The outside option captures three possibilities: not making a transfer, giving money as cash, or using the rival’s network to transfer the money (for an out-of-network transfer only). We also allow for the outside option to vary over time.

The user executes a transfer that maximizes his utility or chooses the outside option. We assume that ε_{ij} is distributed as Type-1 extreme value and is independent across customers and time. This results in a standard multinomial logit formula for the probability of a transfer.

$$P(j) = \frac{exp\,(\alpha_j + \beta p_j)}{\sum_k exp(\alpha_k + \beta p_k) + exp\,(\alpha_0)}$$

4. Estimation

The model is estimated using Maximum Likelihood Estimator. The log-likelihood is given by the equation

$$logL = \sum_{t=1}^{T}\sum_{i=1}^{I} logP(j_{it})$$

where P(j) is given by Equation 1 and j_{it} is the transfer executed by the person i in day t. No transfer is given by j = 0.

For identification, we utilize a change in the fees that occurred on July 5th, 2014. We employ a discontinuity strategy around the price change point. In particular, we consider one week before and one week after the price change. We also observe the introduction of compatibility on September 15th, 2015.

There are four empirically relevant cases:

a) In-network transaction before July 5th, 2014
b) In-network transaction after July 5th, 2014
c) In-network transaction before September 15th, 2015
d) In-network transaction after September 15th, 2015
e) Out-network transaction after September 15th, 2015

It is possible that both the utility of an out-of-network transfer and the outside option to the out-of-network transfer are different than their corresponding in-network counterparts. However, due to the fact the outside option is usually normalized, we set the utilities of in-network and out-of-network transfers to be same. The difference in outside option should then be interpreted as the composite of utility and outside option difference. Our results do not depend on this normalization.

To identify the price coefficient β, we employ a discontinuity approach to analyze the volume of transactions before and after July 5th. The identifying assumption is that the price change was unanticipated by the consumers and was uncorrelated with a discrete demand shock. The former assumption is quite mild and likely to hold since the network does not announce its pricing decision before it is implemented. We also do not see a surge in transactions before July 5th, which would be expected if the price increase was known beforehand. The latter assumption can be tested by looking at transaction patters of the unaffected transfer bins. In particular, we can rule out that the price increase was related to a general surge in demand, since the unaffected bins do not experience increase in demand on July 5th. However, it is still possible, but less likely, that the price increase is correlated with a discrete jump in demand for the specific transfer bins. Such possibility, if true, would bias our coefficient downwards. To identify the difference in the outside option in cases a)-b), c)-d) and e) we use the data on the volumes of transactions for the relevant time periods.

5. Results

Table 5: Estimates of the structural model

		Estimate	Standard error
Intercepts, in-network	0-19,999	-8.351	4.67E-08
	20,000-29,999	-9.8413	5.44E-08
	30,000-39,999	-10.448	5.69E-08
	40,000-49,999	-11.094	6.00E-08
	50,000-99,999	-10.013	5.47E-08
	100,000-199,999	-10.38	6.55E-08
	200,000-5,000,000	-10.355	6.62E-08
Price coefficient		-0.00016672	6.33E-10
2015 fixed effect		0.1898	1.17E-08
After-compatibility fixed effect		0.019732	1.01E-08
Intercepts, out-of-network	0-19,999	-11.393	1.34E-07
	20,000-29,999	-12.462	1.09E-07
	30,000-39,999	-13.237	1.54E-07
	40,000-49,999	-13.993	1.68E-07
	50,000-99,999	-12.306	1.07E-07
	100,000-199,999	-12.867	1.42E-07
	200,000-5,000,000	-12.731	1.10E-07

Using the estimates of the utility parameters from Table 5, we conduct consumer surplus (CS) measurements. The consumer surplus of transfers is given by the following inclusive value equation:

$$CS = \frac{1}{\beta} log \sum_{j=0}^{J} exp\,(\alpha_j)$$

First, we measure total yearly consumer surplus of compatibility at current prices to be 189,527,958 Tanzanian Shillings yearly for 4,359,821 customers, which is approximately 43 Shillings per customer. Next, we set the prices of across-networks transfers to be equal to prices of in-network transfers, to capture a ‘no-roaming charges’ type of regulation adopted in mobile telecommunications in many European countries. If the across-networks transfers were priced at the same level as in-network transfers, consumer surplus would increase to 246,326,089, that is, to 56 Shillings per customer, as reported in Row 3 of Table 6. However, network profits would fall because of substitution between in-network and across networks transfers which is not appropriately captured by the restriction of equal prices.

In principle, the equilibrium impact of no-roaming charges regulation on consumer surplus is theoretically ambiguous. Roaming charges are simply a way to price discriminate between consumers that demand in-network transfers (calls in the telecom context) and those that demand across-networks transfers (calls). As with any price discrimination scheme, the welfare impact of roaming charges, depend on demand elasticity of both consumer groups. We address this question empirically.

We recognize that setting equal prices for in-network and across-networks transfers (as a regulator might impose) would have two consequences: (i) the sending network would increase the price of in-network transfers and decrease the price of out-of-network transfers; (ii) the sending network would pass-through the marginal cost of cash-in to the customer who would take the money out of the network. We expect that the pass-through of the cash-in cost is minimal for in-network transfers since the network can still recoup the cost during the cash-out which has high fees. However, if the money leaves the network, the network cannot collect the cash-out fee and has to pass-through the cash-in cost by increasing the out-of-network transfer fee.

To address the former concern fully, we would need to solve for market equilibrium prices under the restriction that across-networks transfer fees have to equal to in-network transfer fees. The main challenge to this exercise is that the network seems to be pricing dynamically. That is, it charges a lower than the statically optimal price, as suggested by the estimated price elasticity. For this reason, it may be unrealistic to solve for a static equilibrium. At the same time, a dynamics estimation is hard to be identifiable give the available data.

We take a different, simplified approach. We compute common prices that would result in the network generating the same profits in the proposed equal prices regime as in the status quo. Not surprisingly, we find that the regulated common prices fall between unregulated differentiated prices, and are equal to 249.72, 389.87, 370.25, 360.41, 568.03, 662.58, 1969.9 for the respective brackets in Table 5. This pricing leads to a consumer surplus increase of 5.7M. This shows that a regulator setting fees of across-networks transactions should take into account that the network would reoptimize in-network fees. The regulation is still welfare increasing, but the impact is an order of magnitude small than predicted by the naïve calculations of Row 3.

Next, we simulate a set of cases in which the regulator recognizes that, in the status quo, the network’s strategy is to recoup the marginal costs of the cash-in by using the cash-out fee. In the case of across-networks transfers, the originating network cannot collect cash-out fees. To compensate the originating network for its cash-in costs, a regulator would allow the network to surcharge across-networks transfers by an amount equal to the marginal cost of cash-in. A benchmark case would be to set the across-networks transfer fees to the current in-network transfer fees plus the marginal cost of cash-in. The results are presented in Row 5 of Table 6. Consumer surplus from in-network transfers is the same as in the status quo, but consumer surplus from cross-network transfers increases by 234M.

Row 6 shows the results when, besides imposing the marginal cost surcharge for across networks transfers, the network is allowed to change the in-network transfer fees so that profits are kept at the status quo level. It results in 6.2M increase in consumer (and total) surplus, which is greater than in the regime with equal in-network and across-networks transfer fees. Lastly, we consider the benchmark of perfect competition, by setting the in-network and across-networks transfer fees equal to the marginal cost of the cash-in. If the services were priced at marginal cost, total surplus would increase to 136M.

Table 6: Profits and welfare effects of pricing changes (in Tanzanian Shillings)

		Network Profits	CS from in-network transfers	CS from out-network transfers		Change in CS from compatibility status quo	Change in TS from compatibility status quo
				Total	Per customer		
Incompatibility		35.2M	4,033M	0	0		
Compatibility	At present prices (status quo)	42.5M	4,033M	190M	43	0	0
	Across-networks transfer price set to present in-network transfer price	36.1M	4,033M	246M	56	56M	49.6M
	Equal prices across- and in-network with total profits same as at status quo	42.5M	3,986M	243M	55	5.7M	5.7M
	In-network price as in status quo, with added marginal cost surcharge for across-networks transfers	37.6M	4,033M	234M	54	44M	39.1M
	Marginal cost surcharge for across-networks with in-network price adjustment to achieve same profits as status quo	42.5M	3,997M	232M	53	6.2M	6.2M
	Perfect competition	0M	4,107M	252M	58	136M	136M

6. Concluding Remarks

In this paper, we used two natural experiments to estimate demand for in-network and across-networks transfers in the mobile money market in Tanzania. The first experiment used an unanticipated change in transfer fees that enabled us to identify the slope of the demand curve for peer-to-peer transfers. The second experiment, the introduction of technical compatibility across networks, enabled us to estimate the difference in the demand intercepts for in-network and across-networks P2P transfers.

Using the estimated demand, we compute consumer surplus of out-of-network transfers at current price levels to be 190M Shillings per year. We examine the impact of 'no-roaming' charges regulation on consumer surplus. According to naïve estimates, which set across-networks transfers fees equal to in-network transfer fees, fees equalization would lead to 56 million Shillings of extra consumer surplus a year. However, a more complete analysis recognizing that the network would have incentives to raise in-network prices, reveals that the welfare gain from regulation would amount to only 5.7 million Shillings of extra consumer surplus. We also examine a more nuanced version of the regulation which enables the network to impose surcharges on across-networks fees equal to marginal cost of such transactions. We find this regime to be a Pareto improvement over the status quo and generate 6.2 million Shillings of extra consumer and total surplus.

We highlight two lessons from the above results. First, the regulator needs to take into account the equilibrium price readjustments to arrive at the right magnitude of the welfare effects of the regulation. Taking these readjustments into account, the regulation may end up being socially desirable and a Pareto improvement. Second, some level of price discrimination can be welfare improving. We provide evidence that governments should utilize the data on marginal cost structure of the network when designing such regulation.

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