Routledge
Taylor & Francis Group

Economics of Innovation and New Technology

ISSN: 1043-8599 (Print) 1476-8364 (Online) Journal homepage: http://www.tandfonline.com/loi/gein20

Adoption of mobile money and financial inclusion: a macroeconomic approach through cluster analysis

Maëlle Della Peruta

To cite this article: Maëlle Della Peruta (2017): Adoption of mobile money and financial inclusion: a macroeconomic approach through cluster analysis, Economics of Innovation and New Technology, DOI: 10.1080/10438599.2017.1322234

To link to this article: http://dx.doi.org/10.1080/10438599.2017.1322234

Published online: 05 May 2017.

ECONOMICS OF INNOVATION AND NEW TECHNOLOGY, 2017
https://doi.org/10.1080/10438599.2017.1322234

Adoption of mobile money and financial inclusion: a macroeconomic approach through cluster analysis

Maëlle Della Peruta

GREDEG, Université Côte d'Azur, CNRS, Vabonne, France

ABSTRACT

This paper investigates the patterns of adoption of mobile money in emerging and developing countries. Mobile money is a mobile-based service, which provides access to low-cost financial services for people excluded from the banking system. It is designed to overcome the difficulties related to entering the banking system and the unavailability of banking infrastructure. Drawing on macroeconomic comparative and case study analysis conducted by practitioner experts, this study takes a wide macroeconomic approach to the adoption of mobile money adoption in 2011 and 2014, based on the alternative strategy of cluster analysis. We exploit the new technology diffusion frameworks to evaluate dissimilarity among groups of countries with similar levels of adoption of mobile money. We investigate whether adoption of mobile money services are highest in countries where access to formal banking services is lowest. Our analytical results support the predictions in the technology diffusion literature and nuance the potential of mobile money as a tool to counter banking exclusion.

ARTICLE HISTORY
Received 5 April 2016
Accepted 21 November 2016

KEYWORDS
Mobile money; financial inclusion; innovation adoption; similarity/ dissimilarity

JEL CLASSIFICATION
E03; G21; O14; O35; O33; 057

1. Introduction

It is claimed that the development of mobile money services in emerging and developing countries – Kenya, Tanzania, Uganda, Burundi and Rwanda – is having major implications for the financial inclusion of non-banked people. This has resulted in a large and growing body of research on these countries (Lyman, Ivatury, and Staschen 2006; Camner and Sjöblom 2009; Heyer and Mas 2009; Mas 2009; Mas and Morawczynski 2009; Alexandre, Mas, and Radcliffe 2010; Camner, Pulver, and Sjoblom 2010; Mas and Radcliffe 2010; Mbogo 2010; Ndiwalana, Morawczynski, and Popov 2010; Jack and Suri 2011; Mbiti and Weil 2011; Maurer 2011, 2012; Bosire 2012; Di Castri 2013; Di Castri and Gidvani 2014; Evans and Pirchio 2015).

These works support the need to develop new tools, such as mobile money, in order to fight financial exclusion in emerging and developing countries. They investigate the factors that make mobile money successful in order to explain or predict the adoption of this service. They provide assessments of the characteristics of mobile money which contribute to its success (Mobile Network Operators' (MNO) strategies, services offered, service providers' reputation) and analyse the macroeconomic characteristics of the countries observed in order to understand country specificities and adoption behaviours.

These studies have been conducted under the auspices of organizations such as GSM Association (GSMA), the Consultative Group to Assist the Poor (CGAP), the Bill and Melinda Gates Foundation, the United Nations Conference on Trade and Development – UNCTAD or MNOs (Lyman, Ivatury, and

CONTACT Maëlle Della Peruta maelle.della-peruta@unice.fr Université Côte d'Azur, GREDEG, CNRS, 250 rue Albert Einstein – Bâtiment 2, 06560 Vabonne, France

Staschen 2006; Camner and Sjöblom 2009; Alexandre, Mas, and Radcliffe 2010; Camner, Pulver, and Sjoblom 2010; Pénicaud 2012; Di Castri 2013; Pénicaud and Katakam 2013; Di Castri and Gidvani 2014). They consist mainly of country case studies or comparisons between two selected countries (frequently Kenya and Tanzania). The main weakness of these works is that they tend to focus on the same two or three countries and ignore many other countries where take up of mobile money is poor. In addition, country case studies do not allow generalization and do not look objectively at the potential offered by mobile money services for financial inclusion. Finally, by nature of being exploratory or practitioner-oriented studies, most lack of links to the theory (Lyman, Ivatury, and Staschen 2006; Medhi, Ratan, and Toyama 2009; Alexandre, Mas, and Radcliffe 2010; Jack and Suri 2011; Pénicaud 2012; Di Castri 2013).

The object of the present study is to offer a much broader analysis of the adoption and success of mobile money, based on a larger sample of countries in 2011 and 2014. More specifically, we propose a method to assess similarity/dissimilarity in levels of adoption of mobile money. Evans and Pirchio (2015) provide a similar analysis of the success and failure of mobile money adoption, but their study includes investigation of both non-bank and bank-led mobile money. Our results relate only to non-bank-led mobile money as an effective alternative to the banking system to include individuals excluded from banking. A Ward cluster analysis is employed to distinguish the macroeconomic characteristics of countries with similar adoption levels. The clustering gathers countries with similar adoption levels and longevity of mobile money services. It aims to identify both adoption similarity among countries as an outcome of a specific distance function, and characteristic dissimilarities among clusters. A similarity/dissimilarity analysis applied to a larger sample should capture the characteristics of countries where mobile money is successful/unsuccessful and should allow an assessment of the relation between adoption levels, country characteristics and mobile money objectives. The results and conclusions are considered from the perspective of the theoretical new technology diffusion frameworks (David 1975; Allen 1988; Antonelli 1991; Geroski 2000; Caselli and Coleman 2001; Comin and Hobijn 2004; Chinn and Fairlie 2006; Liu and San 2006; Andrés et al. 2010; Comin and Mestieri 2013; Pulkki-Brännström and Stoneman 2013; Allan, Jaffe, and Sin 2014). Ultimately, by assessing general trends related to the success of mobile money adoption, we provide an evaluation of the potential of the mobile money service as a tool enabling financial inclusion.

The paper is organized as follows. Section 2 provides a synthetic review of previous research on mobile money and the new technology diffusion frameworks; Section 3 presents the empirical strategy and describes the sample; Section 4 discusses the main outcomes of the analyses; and Sections 5 and 6 discuss the findings and conclude.

2. Literature review

2.1. Mobile money services, a financial inclusion solution to fight banking exclusion

Mobile money is designed to offer access to financial services for unbanked individuals, especially people in emerging and developing countries with poor banking infrastructures and accessibility (Maurer 2012), described as mobile money for Unbanked [people] (MMU). The main goal of the service is financial inclusion for the financially excluded. Mobile money is based on the offer of simple financial services for customers. It provides access to electronic accounts where customers can deposit cash up to a certain ceiling and from which they can withdraw cash and manage their electronic money. Access and subscription to these accounts and associated services are enabled usually by ownership of a national identity card. Opening, crediting and managing accounts is free (only money transfers are taxed). Mobile money services allow subscribers to send or receive money to/from subscribers using the same service, or banked customers (domestic transfers and/or international remittances) and/or allow bill payments. Mobile money services users can rely on a growing network of service provider employees and retail commercial partners, which allow them to deposit and withdraw cash.

The banking exclusion problem to be addressed can be measured using several characteristics: having a bank account (Toxopeus and Lensink 2007; Ramji 2009; De Koker and Jentzsch 2013); using banking services such as borrowing and saving (Anzoategui, Demirgüç-Kunt, and Pería 2014; Ambrosius and Cuecuecha 2016); frequency of use of banking services such as deposits, withdrawals, transfers, etc. (Allen et al., 2012), or by access to banking services (having a bank account), availability of banking infrastructures (numbers of Automated Teller Machines (ATMs) and bank branches per square kilometre or per individual) or effective use of banking services (deposit and credit levels) (Beck, Demirgüç-Kunt, and Peria 2008; Sarma 2008, 2012; Sarma and Pais 2011; Demirgüc-Kunt and Klapper 2012; Amidzic, Massara, and Mialou 2014).

Mobile money is promoted as fighting against banking exclusion (Maurer 2011) and as offering a solution to at least two major problems: the price of banking services (Morawczynski and Pickens 2009; Mbiti and Weil 2011; Donovan 2012; Arestoff and Venet 2013) and the proximity to banking infrastructures (Morawczynski and Pickens 2009; Camner and Sjöblom 2009; Jack and Suri 2011; Mbiti and Weil 2011). Based on a survey of 18 branchless banking providers in 10 different countries, McKay and Pickens (2010) estimate that the price of branchless banking solutions is 19% lower on average than the price for banking charged by banks. In addition, the network of mobile money providers is offsetting the lack of banking infrastructure and is making financial services reachable. The agents include both the service providers' employees and retail stores (cash-in/cash-out points), which provide users with the possibility of both depositing and withdrawing cash. A 2012 survey conducted by the GSMA on the state of the mobile money industry estimates that in 28 countries, mobile money agents were more numerous than bank branches. This includes Tanzania, with 17,541 mobile money agents compared with only 504 bank branches (Di Castri and Gidvani 2014).

In summary, mobile money is reducing banking exclusion and enabling financial inclusion for individuals disconnected from the banking system (Camner and Sjöblom 2009; Heyer and Mas 2009; Mas 2009; Morawczynski and Pickens 2009; Camner, Pulver, and Sjoblom 2010; Mas and Radcliffe 2010; McKay and Pickens 2010; Jack and Suri 2011; Merritt 2011; Bosire 2012; Di Castri 2013). Mobile money provides financial connection among consumers (Lawack 2013) via what is described as 'branchless banking' (Lyman, Ivatury, and Staschen 2006; Mas 2009) based on financial services provided by private or financial actors other than banks (Dermish et al. 2011).

In 2015, the mobile money service reached 411 million individuals in 93 countries through 271 service offers (GSMA 2015).

The numbers of mobile money users and countries with access to mobile money services are growing constantly (Figure 1). Diffusion of mobile money within countries was in an introductory stage up to 2012, after which it entered the growth stage. The diffusion of mobile money services across countries has continued to increase, but at a slower pace and can be said to be entering a saturation phase (Allan, Jaffe, and Sin 2014). According to GSMA (2015), mobile money services are

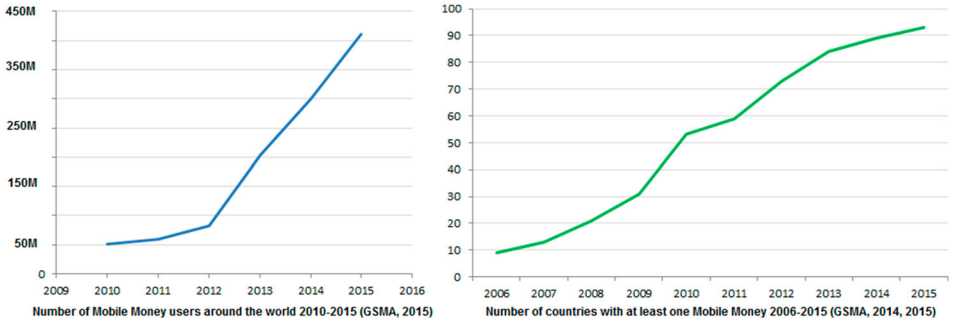

Figure 1. Number of mobile money users around the world and countries with at least one mobile money and number of countries with at least one mobile money.

available in 85% of countries where the number of individuals with accounts with a banking institution is less than 20%, and in 64% of developing countries. Almost every country targeted by mobile money has continued to use the service.

2.2. Key factors of mobile money services adoption

Figure 1 shows that the diffusion of an innovation, in this case mobile money services, is not instantaneous. During the first years of diffusion of mobile money the number of countries and users was small. The growth stage witnessed a rise in both numbers. The epidemic model of technology diffusion explains this slow take off and ensuing period of growth, which followed an S-shaped curve. The spread of an innovation is led by the diffusion of information on its use. Knowledge provided by earlier adopters is the key driver ensuring more adoption. Potential adopters learn about the new technology from previous adopters (Geroski 2000; Pulkki-Brännström and Stoneman 2013; Allan, Jaffe, and Sin 2014); they learn how to use it effectively (Geroski 2000) and about its potential profitability (Mansfield 1961). The greater the number of users, the more information will diffuse about the new technology. Information diffusion can explain both the intensive margin (technology diffusion within countries) and the extensive margin (technology diffusion across countries) (Pulkki-Brännström and Stoneman 2013) based on knowledge spillovers (Feldman 1999; Frenken 2006). The epidemic process of learning is generated by adoption in advanced user countries (Antonelli 1991). The slower technology diffusion during the early introductory stages can be explained also by the heterogeneity of potential users in terms of the benefits from the use of the new technology (Allan, Jaffe, and Sin 2014).

The number of previous users is especially important in the case of mobile money given its particularity as an information and financial technology. The value of mobile money services has increased with the number of users; the multiplication of possible exchanges has made the service more attractive. Network effects are analysed in the technology adoption literature (Claessens et al. 2003; Liu and San 2006; Andrés et al. 2010; Allan, Jaffe, and Sin 2014) and search-theoretic approaches to monetary economics (Kiyotaki and Wright 1993; Katz and Shapiro 1994; Berentsen 1998; Shapiro and Varian 2000; Chou, Lee, and Chung 2004; Rysman 2004; Orléan 2008).

Competition among services providers traditionally is associated with lower prices which stimulate adoption by late adopters and less advanced users (such as rural communities) (David 1975; Antonelli 1991) and promote the diffusion of the new technology (Rouvinen 2006; Andrés et al. 2010). However, in 2015, mobile money services were interoperable (within countries) in only seven countries (GSMA 2015), introducing the possibility of lock-in effects and compatibility problems among competing services (Antonelli 1991). In this configuration of competition without interoperability, network effects are likely to be slowed, discouraging the diffusion of mobile money within countries.

Other determinants identified in the technology diffusion and digital divide literatures might explain mobile money adoption. First, the country's level of income is usually positively associated with a greater technological innovation's diffusion (Caselli and Coleman 2001; Chinn and Fairlie 2006; Andrés et al. 2010), a higher level of income being mainly associated with a better affordability of the new technology. However, mobile money is a low-cost solution targeting poorest people, with only a low purchasing power required. Moreover, since high-income countries are generally early adopters of technological innovations, the speed of innovation is higher for low-income countries than for high-income countries benefiting from lower adoption costs, following a leader–follower model (Andrés et al. 2010).

The level of the telecommunication infrastructure and the availability of infrastructure facilities needed to access a country's mobile money services increase awareness of, diffusion of information on, and formation of compatible skills required to exploit the innovation (Allen 1988; Claessens 2006; Liu and San 2006; Andrés et al. 2010). Potential users need access to a mobile phone and the possibility to use it (mobile network coverage) in order to use the mobile money service (Heyer and Mas

2009; Camner, Pulver, and Sjoblom 2010; Bosire 2012). A sufficient level of interrelatedness with these complementary technologies is required to promote the diffusion of mobile money (Allen 1988; Antonelli 1991).

Education levels are another determinant of adoption identified in these literatures (Caselli and Coleman 2001; Comin and Hobijn 2004; Chinn and Fairlie 2006; Liu and San 2006; Comin and Mestieri 2013). A sufficient skill level among potential users is required to ensure diffusion of a new technology (Antonelli 1991). Education facilitates access to technological services by promoting awareness, ability to use it and assessment of the cost of learning to exploit it. The population in targeted countries must be literate because most mobile money services are SMS-based (M-PESA) or operate via an electronic platform (MTN Mobile Money). It is necessary to know how to read and write, that is, to have the effective abilities and skills needed to adopt and use the services (Camner, Pulver, and Sjoblom 2010; Merritt 2011; Buku and Meredith 2013). Access to education and the level of education achieved can be proxied by the number of years of schooling. In addition, financial education or 'financial literacy' would seem essential for mobile money adoption (Finscope 2009). Financial literacy refers to an awareness, familiarity with and knowledge of financial services based on previous use of financial services (financial experience).

Mobile money services enable distant payments. They are designed particularly to connect distant individuals. In emerging and developing countries, domestic transfers are mostly from urban to rural areas. Rural inhabitants move to the city to find jobs in order to feed their families in rural areas. The transfer of money is facilitated by the mobile money service (Medhi, Ratan, and Toyama 2009; Camner, Pulver, and Sjoblom 2010; Bosire 2012; Buku and Meredith 2013). Similar to some other digital services (Forman, Greenstein, and Goldfard 2003; Chinn and Fairlie 2006), mobile money was designed to reduce rural isolation and to provide a solution for distant payments. The rate of urbanization combined with the rate of labour force participation generating income is an indication of population movement from rural to urban areas and the corresponding need for mobile money transfer services (Camner, Pulver, and Sjoblom 2010; Merritt 2011; Buku and Meredith 2013).

3. Mobile money adoption model: method and data

To address the level of agreement between what determines mobile money adoption and the objective of financial inclusion, we analyse 24 countries in the year 2011, and 31 in year 2014, with at least one non-bank-led mobile money service, in order to understand the key factors related to adoption of mobile money and to evaluate how they equate to MMU service's supported goals.

3.1. Cluster analysis

Cluster analysis enables data to be grouped and organized based on their similarity. The objective of the cluster analysis is to create several distinct groups with similar study objectives. Thus, the groups are constituted by maximizing the interclass distance and minimizing the intraclass distance. The purpose of the adoption factor analysis is to regroup countries according to their level of adoption and the number of years since introduction of the first MMU service, and to merge countries with homogeneous adoption characteristics. This will identify the group with the highest adoption and its characteristics. We use Ward's minimum-variance method which is preferred over other hierarchical cluster algorithms, because of its better predictive potential which has been tested in numerous studies based on Euclidean distance or the Rand Index, for example (Ferreira and Hitchcock 2009; Becker, Kronthaler, and Wagner 2011). The number of clusters initially is unknown and the analysis starts by attributing each individual to a distinct cluster. The clusters are merged progressively according to a minimized variance between two clusters being merged. Ward's cluster method stops when only one cluster remains. Different methods can be used to determine the optimal number of clusters. In this analysis, three are tested: the Duda and Hart Index, the Calinksi and

Harabasz Index and the dendrogram. The Calinksi and Harabasz Index is defined as:

$$\mathrm{CH}(K) = \frac{\mathrm{trace}(B)/(K-1)}{\mathrm{trace}(W)/(N-K)},$$

where N is the number of observations, K is the number of groups, *trace(B)* is the between-cluster sum of squared distances and *trace(W)* is the within-cluster sum of squared distances. Then the variance ratio criterion (VRC), w_k is computed. The value of the VRC is low when the number of groups is optimal.

The Duda and Hart Index is expressed as:

$$\mathrm{DH} = \frac{J_1^2(m)}{J_2^2(m)},$$

where $J_1^2(m)$ is the within-cluster sum of the squared errors of the mth cluster, $J_2^2(m)$ the within-cluster sum of the squared distances when the mth cluster is optimally divided into two. The value of the Duda and Hart Index is high when the number of groups is optimal.

These index results (Appendix 2) are completed and checked visually based on the resulting dendrogram.

In order to evaluate the robustness of the cluster analysis, different clustering procedures are used: nearest neighbour and furthest neighbour methods. Changing the procedure is generally recommended to check the robustness of a cluster analysis (Everitt et al. 2011). The three procedures can be expected to provide slightly different but very similar results (Mooi and Sarstedt 2011). The results of the nearest neighbour and furthest neighbour procedures are presented in Appendix 1. The Ward and furthest neighbour methods provide fairly similar results – the differences applying to six countries in 2011 and seven in 2014. In order to verify significant differences between clusters, a one-way ANOVA is performed to calculate the cluster centroids. According to this analysis, the adoption variable is significant in both 2011 and 2014, and service life time is significant in the 2011 analysis (results provided in Appendix 3).

3.2. Data collection

In this cluster analysis, countries are regrouped according to their level of mobile money adoption and the number of years since the first MMU service was implemented. A database of mobile money adoption is being compiled and is available from the International Monetary Fund (IMF) via the Financial Access Survey (FAS). This database provides the number of mobile money accounts in the countries in which the service has been implemented. The 2014 analyse exploits data only from this database. The 2011 analysis study exploits information from several sources including: reports,[1] interviews,[2] case studies,[3] corporate annual reports,[4] and conference presentations.[5]

The number of years since the first MMU service was implemented was obtained from the GSMA Mobile Money Tracker Database, which provides year and month of implementation. This allows the numbers of years to end 2011 and end 2014 to be calculated.

Macroeconomic variables for country characteristics are extracted from World Bank databases including the World Development Indicators, Education Statistics, Jobs and Findex.

3.3. Choice of variables

To understand the determinants of mobile money adoption, the chosen variables are drawn from the technology diffusion literatures cited previously (Table 1). Banking factors, in terms of accessibility, availability and use of the banking system, are taken into account. Availability of banking infrastructures, access to banking services and the complete Index of Financial Inclusion (IFI) are calculated based on the calculation developed by Sarma and Pais (2011).

Table 1. Features of mobile money adoption.

Features	Variables	Description	Data source
Epidemic technology diffusion	Spillovers and network effects	Number of previous adopters	IMF
Competition	Competition	Number of mobile money platforms	GSMA
Availability of infrastructures	Availability of the banking infrastructures	Aggregation of the number of ATMs per 1000 km^2 and the number of bank branches per 1000 km^2	WDI
	Access to the banking system	Index calculated from the number of bank accounts per 1000 adults	WDI
	Mobile coverage	Population covered by mobile cellular network (%)	ITU
	Mobile penetration	Mobile cellular subscriptions per 100 people	WDI
Socio-demographic factors	Level of income	GNI per capita, PPP Current inter. $	WDI
	Urban growth	Urban population growth (annual %) Usage and Accessibility Index	WDI
	Labour force	Labor force participation rate (% of total adult population)	WDI
	Level of education	Average number of years of schooling of the population	Education Statistics World Bank

Education level is expressed as the population's average number of years of schooling. In the case of missing information for 2011, data for 2009 or 2010 are used. The rate of urbanization growth, combined with the rate of labour force participation are used to measure the movement of population from rural to urban areas and the need for distant payments (Medhi, Ratan, and Toyama 2009; Camner and Sjöblom 2009; Bosire 2012; Buku and Meredith 2013). Finally, mobile penetration, expressed as mobile cellular subscriptions per 100 people, and mobile coverage, expressed as percentage of the population covered by a mobile network, are used to measure the level of available infrastructure, which is required to use mobile money services.

3.4. Sample description

The samples observed (Table 2) are composed of 24 developing and emerging countries in 2011 and 31 such countries in 2014 (18 of which are the same in both samples), with at least one non-bank-led mobile money system. In 2011 Democratic Republic of Congo, Guyana, Lesotho, Malawi, Niger, Swaziland, Togo, Tonga and Zimbabwe had no MMU service; Burundi, Colombia, Mongolia, Paraguay, Sierra Leone and Thailand are observed in 2011, but not 2014 because of lack of available data on mobile money adoption. In both 2011 and 2014, with the exception of Benin, Malaysia and Morocco where adoption decreased or stagnated, all countries show high growth of MMU service adoption.

Among the descriptive statistics, the factors linking adoption behaviour with banking inclusion are not easily determined. Some countries with relative high IFIs seem also to present relatively high level of adoption of mobile money. For instance, Thailand, Philippines and Kenya with relatively high IFI in 2011, report relatively high levels of adoption of mobile money. Fiji, Kenya and Rwanda present the same profile in 2014. However, Tanzania and Senegal are ranked very low for IFI, but show relatively high levels of MMU service adoption in 2011. The profiles of Uganda and Zimbabwe present the same characteristics in 2014.

The sample is composed also of countries with relatively low IFI, and relatively low levels of adoption of mobile money. Afghanistan, Sierra Leone are low banking included countries in 2011 and record relative low levels of adoption, this applies to Guinea-Bissau and Benin in 2014.

According to the descriptive statistics, it is not possible to determine country profiles or to draw conclusions. Countries need to be grouped according their level of adoption of mobile money and the service life of the MMU. Grouping countries with similar characteristics will allow comparison and provide an understanding of their differences.

Table 2. Level of mobile money adoption and Index of Financial Inclusion.

Country	Date of the first launch of MMU	Adoption of MMU in 2011 (Accounts per 100 adults)	Adoption of MMU in 2014 (Accounts per 100 adults)	IFI in 2011	Rank IFI in 2011	IFI in 2014	Rank IFI in 2014
Afghanistan	2008	0.794	8.932	0.024	23	0.031	28
Benin	2010	2.898	2.693	0.079	17	0.086	18
Burkina Faso	2009	0.693	11.511	0.076	18	0.068	23
Burundi	2010	0.543		0.055	21		
Colombia	2009	5.310		0.196	7		
Congo Dem. Rep.	2012		26.412			0.005	31
Côte d'Ivoire	2008	17.678	75.996	0.113	12	0.081	20
Fiji	2010		55.817			0.416	3
Guinea-Bissau	2010		0.023			0.033	27
Guyana	2013		1.203			0.241	9
Indonesia	2007	4.755	19.561	0.182	9	0.410	4
Kenya	2007	79.389	98.532	0.241	6	0.245	8
Lesotho	2012		55.305			0.119	15
Liberia	2011	2.029	10.527	0.110	13	0.086	19
Madagascar	2010	7.300	15.726	0.018	24	0.025	29
Malawi	2012		8.154			0.096	17
Malaysia	2007	2.528	2.695	0.583	2	0.723	1
Mali	2010	4.015	27.664	0.047	22	0.059	25
Mongolia	2010	5.965		0.303	5		
Morocco	2010	0.346	0.006	0.351	3	0.462	2
Namibia	2010		12.817			0.212	11
Niger	2012		16.871			0.014	30
Nigeria	2003	3.618	7.082	0.191	8	0.206	12
Paraguay	2010	3.413		0.138	11		
Philippines	2004	13.677	16.433	0.305	4	0.384	6
Rwanda	2010	4.974	92.449	0.176	10	0.219	10
Samoa	2011		39.262			0.398	5
Senegal	2008	10.638	31.402	0.067	19	0.102	16
Sierra Leone	2009	1.909		0.063	20		
Swaziland	2011		29.230			0.179	13
Tanzania	2008	35.990	147.655	0.094	15	0.062	24
Thailand	2004	12.403		0.754	1		
Togo	2013		4.637			0.128	14
Tonga	2011		12.729			0.363	7
Uganda	2009	11.649	93.401	0.102	14	0.080	21
Zambia	2009	5.889	57.838	0.093	16	0.078	22
Zimbabwe	2011		47.941			0.051	26

4. Results

In order to understand these first observations, we run a cluster analyses to regroup countries with similar mobile money adoption level and service life.

4.1. Results from the 2011 analysis

The dendrogram (Figure 2), VRC and the Duda and Hart Index (Appendix 2) are used to distinguish the groups based on cluster analysis, for 2011, where the heights of the links in the dendrogram provide information on the level of proximity among the groups. The number of groups selected was derived by observing the dendrogram and the Duda and Hart Index indicating the same optimum number of clusters.

According to these observations, there are five clusters for 2011 (Table 3); two including only one country, Kenya and Tanzania, present much higher adoption which is not comparable to the adoption level in the other countries observed.

This study focuses on different groups of countries with similar mobile money adoption and service life (Table 4). Kenya and Tanzania, which comprise separate distinct groups in 2011, are excluded from the 2011 study. Kenya and Tanzania have been investigated frequently (Camner

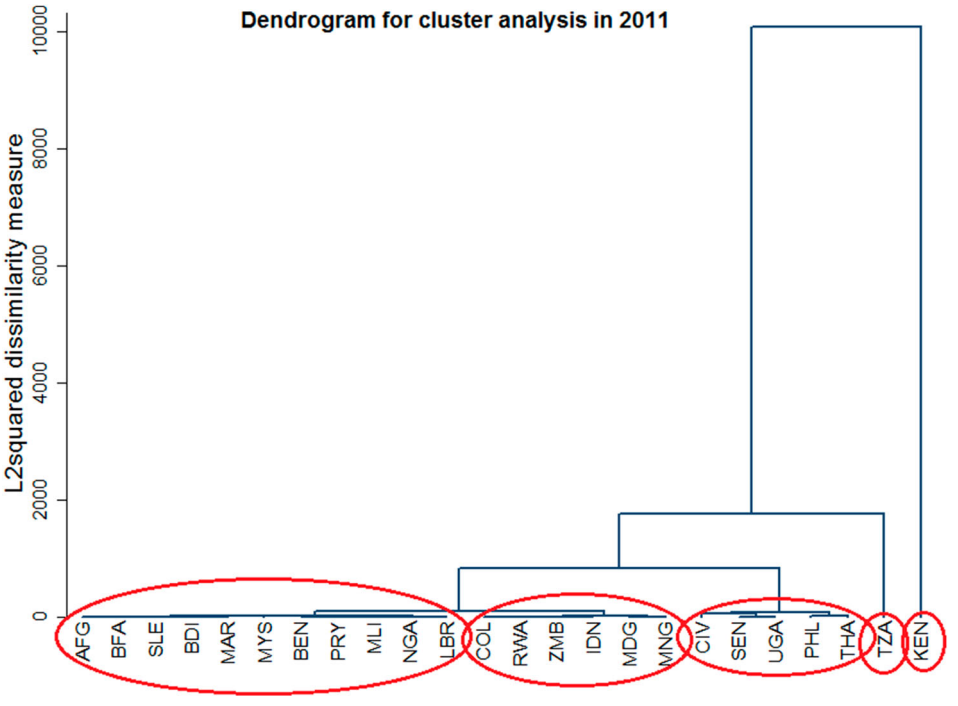

Figure 2. Dendrogram for cluster analysis in 2011.

and Sjöblom 2009; Heyer and Mas 2009; Mas 2009; Jack and Suri 2011; Bosire 2012). Numerous arguments have been proposed in case studies of these two countries to explain mobile money success. The sources of these success factors vary between MMU and service providers' characteristics and country specificities. MMU and service providers' characteristics consist mainly of large enrolment of retail businesses as agents (Camner and Sjöblom 2009; Mas and Morawczynski 2009), strong control over agents' distribution (Mas and Morawczynski 2009), and trust in the MMU provider (Camner and Sjöblom 2009; Heyer and Mas 2009). Country characteristics include mainly a relatively available banking system (Camner and Sjöblom 2009), good financial services awareness among a large population (Camner and Sjöblom 2009), increased urbanization (Heyer and Mas 2009) and a high level of mobile penetration and wide mobile network coverage (Mas and Morawczynski

Table 3. Ward clusters in 2011 and 2014.

Ward cluster in 2011	
Five clusters	
Cluster 1	LBR-PRY-BFA-BDI-MAR-AFG-BEN-NGA-SLE-MYS-MLI
Cluster 2	IDN-ZMB-MDG-RWA-COL-MNG
Cluster 3	UGA-SEN-PHL-THA-CIV
Cluster 4	TZA
Cluster 5	KEN
Ward clusters in 2014	
Six clusters	
Cluster 1	AFG-MWI-NGA-BFA-LBR-NAM-TON-IDN-MDG-NER-PHL
Cluster 2	BEN-MYS-TGO-GNB-MAR-GUY
Cluster 3	ZAR-MLI-SEN-SWZ
Cluster 4	FJI-LSO-ZMB-WSM-ZWE
Cluster 5	KEN-CIV-RWA-UGA
Cluster 6	TZA

Table 4. Adoption of mobile money.

	Level of adoption (Accounts per 100 adults)	Service life of MMU (year)		Level of adoption (Accounts per 100 adults)	Service life of MMU (year)
Cluster 1	2.071	1.645	Cluster 1	12.71	4.98
N	11	11	*N*	11	11
Std. dev.	1.331	1.061	Std. dev.	4.056	3.338
Cluster 2	5.699	1.916	Cluster 2	1.876	3.75
N	6	6	*N*	6	6
Std. dev.	0.92	1.087	Std. dev.	1.808	2.243
Cluster 3	13.209	5	Cluster 3	28.67	4.02
N	5	5	*N*	4	4
Std. dev.	2.733	3.472	Std. dev.	2.152	0.727
Cluster 4	35.99	3.2	Cluster 4	51.23	4.1
N	1	1	*N*	5	5
Std. dev.	–	–	Std. dev.	7.671	1.353
Cluster 5	79.39	4.3	Cluster 5	90.09	6.13
N	1	1	*N*	4	4
Std. dev.	–	–	Std. dev.	9.771	1.164
			Cluster 6	147.6	6.66
			N	1	1
			Std. dev.	–	–

2009). Both Kenya and Tanzania seem to present favourable specific conditions enabling adoption and are excluded from further analysis.

Cluster 1 includes those countries where the service is relatively new (introduced for approximately 18 months) and not wide-spread (2.07 accounts per 100 adults). Cluster 2 includes countries where the services was introduced between 18 and 24 months earlier on average, similar to Cluster 1, but where MMU is more diffused (5.69 accounts per 100 adults). Cluster 3 includes countries where the service has been available for 5 years, and is better spread (more than 13 accounts per 100 adults). All the results are confirmed by a *t*-test which reveals significant differences.

Comparison of country characteristics between different clusters identifies the factors that might explain the differences in the level of MMU adoption (Table 5 and Figure 3).

We cannot account for MMU service and providers' characteristics because it is not possible to ascertain the rates of adoption related to each service provider. We also cannot compare MMU service quality. Our analysis focuses on country specificities. A first observed difference involves banking infrastructure availability between Cluster 3 and the other two clusters. Cluster 3 has higher availability (0.203 compared to 0.058 in Cluster 1 and 0.069 in Cluster 2). This observation is not compatible with the objective of mobile money, which is to include the banking excluded, but confirms the results of some other case studies. Agents responsible for opening and crediting users' electronic accounts with amounts presented in cash need to be in the vicinity of bank branches or ATMs in order to manage their liquidity (i.e. deposit users' cash on their own account and withdraw funds in order to provide enough cash to customers) (Camner and Sjöblom 2009; Mas and Morawczynski 2009; Camner, Pulver, and Sjoblom 2010; Mas and Radcliffe 2010; Merritt 2011; Bosire 2012). Cluster 3 is the cluster with the highest mobile money service time, providing evidence of the need for MMU providers to access banking infrastructures to run the service. In addition, Cluster 3 countries have better mobile network coverage: 96% of the population covered by the mobile network on average in Cluster 3, compared to 74% in Cluster 1 and 75% in Cluster 2. This difference also might explain why these countries implemented the service at an earlier date. To deploy their financial services and to ensure adoption, MMU providers need to connect a significant part of the global population via the mobile network. It might also explain the higher level of adoption in Cluster 3, despite the greater longevity of the MMU service.

Cluster 3 also shows higher mobile penetration compared to the other two clusters. Mobile penetration and associated network coverage are required not only to use the mobile money service

Table 5. Clusters' characteristics.

Clusters 2011	Availability of Banking Infra.	Bank Accounts (% of Adult Pop.)	Index of Financial Inclusion	Mobile Penetration	Mobile Coverage	Labour Force	Urban Growth	Years of Schooling	GNI/ capita, PPP inter. $
Cluster 1	0.058	21.73	0.156	73.14	74.09	64.69	3.90	5	5246.36
N	11	11	11	11	11	10	11	9	11
Std. dev.	0.091	17.726	0.168	33.115	29.74	13.035	1.35	2.524	7034.56
Cluster 2	0.069	31.23	0.161	74.54	75.5	74.33	3.47	7.48	6810
N	6	6	6	6	6	6	6	5	6
Std. dev.	0.073	24.73	0.097	31.572	29.029	10.968	1.196	1.929	5149.13
Cluster 3	0.203	29.35	0.268	84.51	96.2	71.54	3.37	5.9	6112
N	5	5	5	5	5	5	5	5	5
Std. dev.	0.259	25.411	0.287	26.575	4.816	5.922	1.794	2.364	5597.20
Cluster 2014									
Cluster 1	0.2748	40.48	0.1722	75.13	89.55	68.6	3.7677	5.1273	4310.90
N	11	11	11	11	9	11	11	11	11
Std. dev.	0.374	31.645	0.152	31.363	13.739	12.493	1.633	2.718	3777.17
Cluster 2	0.2023	79.51	0.2791	97.54	91	68.32	2.8289	5.8833	7345
N	6	6	6	6	6	6	6	6	6
Std. dev.	0.231	910.81	0.265	36.114	13.084	10.593	1.318	2.67	9026.74
Cluster 3	0.0699	20.33	0.086	93.42	79.67	69.23	3.6372	4.175	3282.5
N	4	4	4	4	3	4	4	4	4
Std. dev.	0.094	181.08	0.073	41.475	25.813	8.052	1.58	2.202	3174.84
Cluster 4	0.1735	58.21	0.2128	80.87	81	67.3	2.0856	7.96	4512
N	5	5	5	5	3	5	5	5	5
Std. dev.	0.165	494.414	0.179	19.925	3	17.358	1.676	2.011	2612.99
Cluster 5	0.1804	41.22	0.1565	74.14	96.5	75.23	4.841	4.825	2365
N	4	4	4	4	4	4	4	4	4
Std. dev.	0.174	465.27	0.088	23.127	5.066	9.168	0.965	1.304	790.29

(Allen 1988; Antonelli 1991; Heyer and Mas 2009; Camner, Pulver, and Sjoblom 2010; Bosire 2012) but also to ensure better diffusion of information about technological innovations (Claessens 2006; Liu and San 2006; Andrés et al. 2010).

The higher level of adoption in Cluster 3 can be explained in part by the fact that the countries in this cluster have had access to mobile money services for a longer time than the countries in the

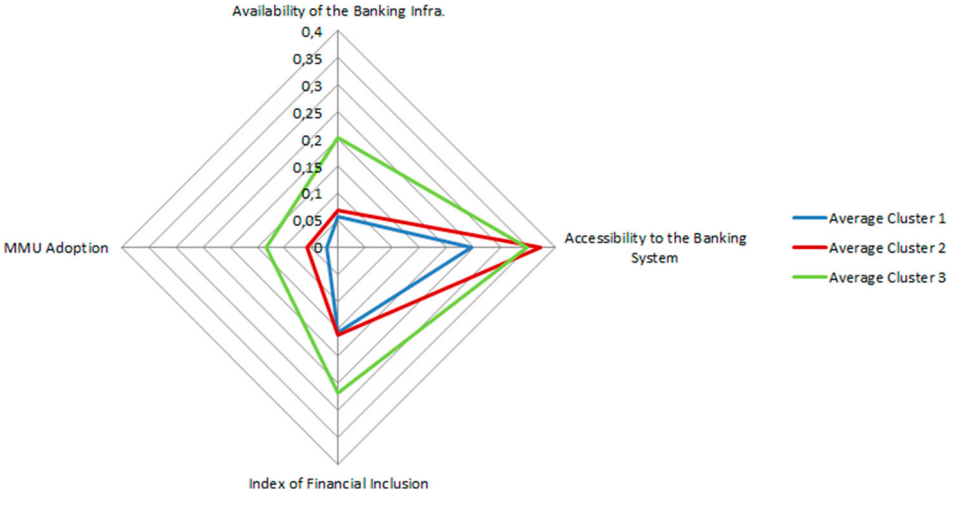

Figure 3. Graphic analysis of adoption and financial inclusion.

other two clusters. Clusters 1 and 2 have benefited from access to this service for around the same length of time, but present different levels of adoption, suggesting the relevance of comparing these two clusters. Cluster 2 presents several specificities compared to Cluster 1. First, the countries in Cluster 2 are more widely included in the banking system, measured by having a bank account (on average, 31% of the population in Cluster 2 have a bank account, compared with 21% in Cluster 1). This does not align with the objectives of the MMU service. However, residents with bank accounts use mobile money services and are relatively more familiar with them, which correspond to financial literacy being a determinant of mobile money adoption (Camner and Sjöblom 2009; Finscope 2009). This has been highlighted in other studies which show that early adopters of mobile money services are mainly banked people (Jack and Suri 2011). Second, the countries in Cluster 2 are better educated (more than 7 years of schooling on average compared with 5 years in Cluster 1). Potential users require the necessary abilities to adopt mobile money, mainly literacy skills (Camner, Pulver, and Sjoblom 2010; Merritt 2011; Buku and Meredith 2013). Education facilitates access to technological services in terms of awareness, user ability and cost of learning (Caselli and Coleman 2001; Comin and Hobijn 2004; Chinn and Fairlie 2006; Liu and San 2006; Comin and Mestieri 2013). Again, this confirms other studies showing that early adopters are better educated (Van den Bulte 2000; Chia et al. 2006; Ndiwalana, Morawczynski, and Popov 2010; Tobbin and Adjei 2012). The level of income is higher in Cluster 2 than in Cluster 1, attesting to the positive relationship with the technological innovation diffusion (Caselli and Coleman 2001; Chinn and Fairlie 2006; Andrés et al. 2010). Cluster 2 presents a higher rate of labour participation, which might confirm the need for people to send a part of their earnings to their families. However, this observation is not confirmed by the rate of urban growth, which is roughly the same across all three clusters.

Since competition among mobile money service providers was limited in 2011 (most of the countries studied had only 1 mobile money platform in 2011), it is not possible to draw conclusions about the impact of competition at this time. However, we can deduce some tendencies related to the inclusive potential of mobile money. Its stated aim is to increase financial inclusion and yet Cluster 3, which has the highest level of adoption, is also the cluster with the highest IFI.

4.2. Results from the 2014 analysis

According to the Duda and Hart Index, the VRC and the dendrogram observation in 2014 (Figure 4), we obtain six clusters (Table 3), one being composed only by Tanzania, which, again, presents a significantly higher level of adoption than the other countries studied. In the 2014 analysis, Kenya is included in Cluster 5. Kenya recorded a lower level of mobile money adoption than Tanzania, which contrasts with the findings from other studies (Camner and Sjöblom 2009; Camner, Pulver, and Sjoblom 2010; Bosire 2012) that analyse Kenya and Tanzania together. We need to re-examine the factors explaining the huge success of mobile money in Kenya.

The 2011 cluster analysis produced very different results among clusters; the 2014 analysis study shows that among the five clusters studied, three stand out as very different (Tables 4 and 5).

Cluster 2 is characterized by the lowest level of MMU adoption (1.876 accounts per 100 adults) and the shortest service time (3.75 years on average). The three countries recording stagnating or decreased levels of adoption between 2011 and 2014 (Benin, Malaysia and Morocco) are in Cluster 2. The countries in this cluster also have the highest IFI (0.28), the highest access to the banking system (0.31) and high availability of banking infrastructures (0.20). Based on the presence of a relatively efficient banking system, these countries have no need for a financial alternative such as mobile money. The inability of a sufficiently efficient banking system to compete might explain both the low level of MMU adoption and the short service time in these countries.

Cluster 3 is defined by the lowest banking inclusion (Figure 5) – the lowest IFI (0.09), lowest access (0.07) and lowest availability (0.07) of banking services – and fairly low level of adoption of mobile money (28.68 accounts per 100 adults). Since mobile money should represent a financial alternative to banking services, banking system inclusiveness in these countries seems to be too

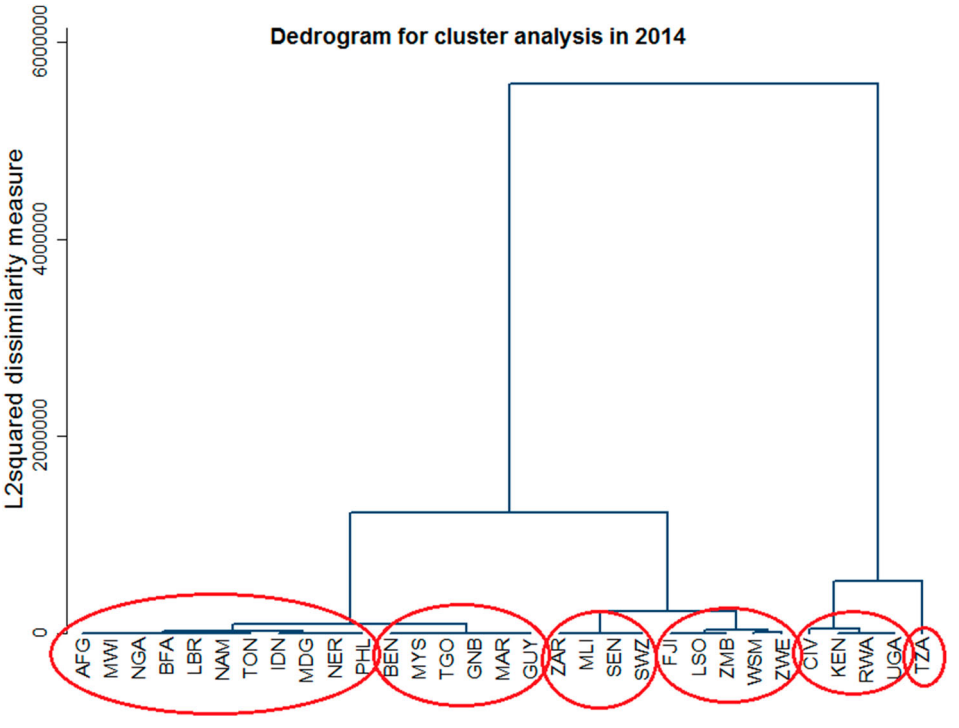

Figure 4. Dendrogram for cluster analysis in 2014.

low to enable adoption of MMU. Indeed, as already mentioned, mobile money agents need to have access to a relatively well developed banking infrastructures in order to manage customers' cash. Thus, the diffusion of a network of agents is limited by lack of access which, in turn, restricts mobile money diffusion. Countries in Cluster 3 also present lack of experience of financial services; they record the lowest index of accessibility to the banking system – on average, only 20.33% of the adult population hold a bank account. This lack of banking experience, which could be considered

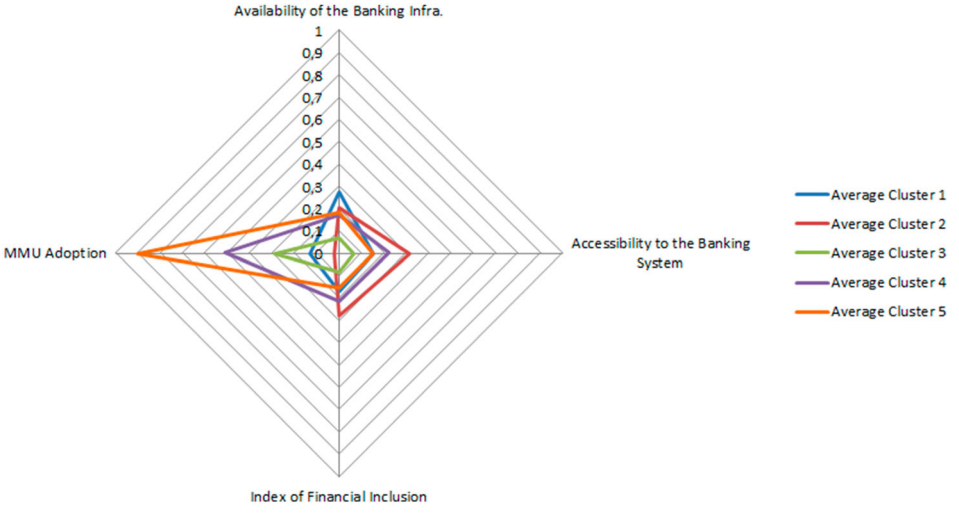

Figure 5. Graphic analysis of adoption and financial inclusion.

to be lack of financial literacy, might be an obstacle to adoption of financial innovations such as mobile money (Camner and Sjöblom 2009; Finscope 2009). In addition, Cluster 3 includes countries where the mobile coverage (79.7% of the population covered) is the smallest on average. The low mobile coverage does not allow mobile money to be an effective alternative to the banking system. Finally, Cluster 3 records the smallest number of years of schooling (4.2) on average. Education level is directly related to the capability to use technological services and mobile money (Caselli and Coleman 2001; Comin and Hobijn 2004; Chinn and Fairlie 2006; Liu and San 2006; Comin and Mestieri 2013).

Cluster 5 records the highest level of adoption (90.09 accounts per 100 adults), but also the longest service time (6.12 years). This cluster has the highest rate of mobile network coverage (96.5%) combined with low availability of the banking infrastructures (0.18). It presents the highest rates of labour force participation (75.22%) and urban growth (4.84%). Countries in Cluster 5 also record the highest number of live platforms (5.75 on average). High levels of competition between MMU service providers could reduce the price of this service (Rouvinen 2006; Andrés et al. 2010) ensuring higher levels of adoption. Rwanda, Uganda and Kenya are neighbouring countries which benefit from cross-border mobile money remittance services. This interoperability might explain also why competitive platforms could accelerate network effects. These observations are consistent with the hypotheses in the technology diffusion literature. Indeed, mobile money corresponds to the need for money transfer services for people leaving rural areas to find jobs in urban areas.

Cluster 4 raises some questions. It records a relatively high level of MMU service adoption (51.23 accounts per 100 adults) with a fairly short service time (4.1 years). It presents some favourable conditions for wide adoption. Cluster 4 groups countries where over half of the adult population, on average, has a bank account (58.21%), which indicates a relatively high level of financial literacy; where banking infrastructures are not widely available (0.17); and where the average number of years of schooling is the highest (7.96) among our clusters which facilitates adoption. In addition, Cluster 4 presents relatively high rates of mobile penetration (80.8%) and mobile network coverage (81%), which offer an efficient alternative to the low availability of banking infrastructures (0.17). Based on these observations, MMU service adoption may continue to increase in future years. However, this cluster records the lowest rates of urban growth (2.08%) and labour participation (67.3%), which suggests a lower level of need for money transfers compared to the other clusters. While Cluster 4 presents some good indicators of growing adoption, it also presents some obstacles, which might be a barrier to mobile money adoption continuing to increase at current levels.

Cluster 1 is very specific. It shows a relatively low level of mobile money adoption (12.71 accounts per 100 adults), while, on average, the countries in this cluster have been familiar with mobile money for some time (4.98 years). However, it seems that mobile money has not met with success in these countries, which have some particular characteristics. The cluster presents quasi similar indicators to Cluster 5 with the exception of a higher index of availability of banking infrastructures (and the highest (0.27)) among our clusters. This lack of need for a financial alternative might explain the low level of adoption in this cluster.

The relationship between a high level of income and a high level of mobile money diffusion is not verified anymore. Clusters with the highest levels of income are not those where the mobile money is the most spread (Clusters 1 and 2). In return, Cluster 5 recording the lowest level of income is also the cluster where the mobile money is the most diffused. This observation can be explained but the nature of the mobile money services (low-cost solutions) and by the 'catching up' process of low-income countries as adopters followers (Andrés et al. 2010).

To summarize, we would underline that the results of the 2011 analysis are predictive. Most of the countries observed are in a similar cluster in 2014. Tanzania and Kenya continue to show the highest levels of mobile money adoption in 2014, followed by Côte d'Ivoire and Uganda which are in Cluster 3 in 2011 and in Cluster 5 in 2014. Only the Philippines moves from Cluster 3 in 2011 to Cluster 1 in 2014. Cluster 1 in 2011 and Clusters 1 and 2 in 2014 include those countries with the lowest levels of MMU adoption (Afghanistan, Benin, Burkina Faso, Liberia, Malaysia, Morocco and Nigeria).

All except three countries show high increases in the level of mobile money adoption between 2011 and 2014 (intensive margin). This is consistent with the epidemic diffusion of technological innovation model: potential adopters learn about the new technology from previous adopters (Geroski 2000; Pulkki-Brännström and Stoneman 2013; Allan, Jaffe, and Sin 2014), and learn how to use it effectively (Geroski 2000) and learn about its profitability (Mansfield 1961). The value of mobile money services increases with the number of users, making them attractive based on multiplication of possible exchanges (Claessens et al. 2003; Liu and San 2006; Andrés et al. 2010; Allan, Jaffe, and Sin 2014).

Countries registering the highest level of adoption in 2014 are neighbours (Kenya, Tanzania, Rwanda and Uganda). This suggests knowledge spillovers among these countries, the extensive margin (Pulkki-Brännström and Stoneman 2013), and a greater diffusion of information between neighbouring countries. In addition, these countries allow mutual international remittances, which renders their mobile money services interoperable (GSMA 2015) and reinforces the service's potential.

5. Discussion

This work investigated the characteristics of countries sharing the same levels of adoption of mobile money services and exploited the technology diffusion literature in order to determine the accord between the preconditions for mobile money adoption and its objective of financial inclusion.

Analyses of countries in 2011 and 2014 support the predictions of the technology diffusion literature. Almost all the hypotheses in previous studies are confirmed by our results. The only differences are related to 2011 and can perhaps be explained by the increased mobile penetration between 2011 and 2014 in the countries studied. Mobile telephony has become a widely diffused technology and no longer constitutes an obstacle to mobile money adoption.

However, our results highlight a paradox. The mobile money service was designed to fight financial exclusion through the provision of low-cost and easily accessible financial services. However, mobile money services require a relatively inclusive banking system and, thus, cannot be considered to be independent of the formal banking system. Mobile money provides a 'banking beyond branches' solution (Alexandre, Mas, and Radcliffe 2010), but to run their financial services activities, mobile money service providers need access to an appropriate and available banking infrastructure, in order, particularly, to manage their cash and provide a sufficiently good quality service to ensure adoption. Also, the adoption of financial services, such as mobile money, requires prior knowledge and experience of such services. Thus, in contrast to its objective of overcoming financial exclusion, mobile money has not achieved the most success in countries suffering the highest level of lack of banking access. However, there are differences between the 2011 and 2014 analyses. The dependence of mobile money on the banking system is more visible in 2011, during the launch of mobile money services. This dependence exists in 2014, but is less pronounced as shown by the cases of Kenya and Tanzania. In 2011, Kenya recorded a higher level of adoption than Tanzania, which was explained in previous studies by the greater efficiency of the Kenyan banking system (Camner, Pulver, and Sjoblom 2010; Bosire 2012). In 2014, Kenya still had a stronger inclusive banking system than Tanzania, but showed a lower level of mobile money adoption, confirming lower dependence of mobile money services on the banking system. Although this would constitute a step in the direction of increasing financial inclusion, it is a nuanced finding. A recent study (Evans and Pirchio 2015) concludes that countries experiencing what they describe as 'ignition with explosive growth' are also those with the poorest infrastructures, which is not supported by the results of the analyses in this paper.

Mobile money services' dependence on the banking system generates two kinds of issues. In countries heavily affected by banking exclusion, the difficulty for mobile money service providers to implement their service reinforces the country's financial exclusion. This leads to double exclusion

of low-banking countries: banking exclusion and exclusion from innovative financial solutions (such as mobile money). On the one hand, these countries are likely increasingly to be excluded from financial services by the fact that currently designed solutions are not totally independent of the existing banking infrastructures. On the other hand, dependence on the banking system, which necessitates a sufficiently inclusive system, reinforces the double exclusion problem for populations in low-banked countries. Also, if mobile money providers succeed in establishing their financial services in low-banked countries, this innovation is less likely to be adopted in these countries compared to better banked countries. Mobile money adoption is dependent on prior financial experience and the financial knowledge of potential users.

The mobile money paradox highlights issues related to financial literacy and information diffusion. Awareness, knowledge about the technological innovation, and general and financial education appear to be key elements in the adoption of mobile money as an instrument facilitating financial inclusion. Populations must be aware of the availability of financial and mobile money services. To inform and educate populations, mobile money service providers must understand the importance of deploying a significant network of agents to act as educators. MMU service providers and practitioners maintain it is necessary to deploy an extensive network of agents in order to raise awareness and educate people about mobile money and financial services (Davidson and Leishman 2010; McKay and Pickens 2010; Flaming, McKay, and Pickens 2011). Furthermore, local agents, licensed and delegated by MMU providers include employees or owners of retail shops who, often, are already known by the local population. Their proximity to local populations enables them to educate these individuals and promote mobile money services within a climate of trust and confidence, all factors leading to mass adoption of mobile money.

6. Conclusion

This work investigated the characteristics of countries with similar levels of adoption of mobile money services. We employed a macroeconomic approach based on cluster analyses of broader samples than used in the case study methods employed for exploratory and practitioner-oriented investigations. Drawing on technology diffusion theories, this work assessed the main trends explaining differences in adoption levels among the countries observed.

The results of the cluster analyses support the predictions in the technology diffusion literature. Most of the observations in the case studies are confirmed by this larger-scale work. However, our analyses do not support the idea of financial inclusion based on mobile money. The trends observed, which link adoption levels and banking system efficiency, do not allow firm conclusions about the real potential of mobile money. However, our observation of decreasing dependence of mobile money services on the banking system is promising for achieving the objective of financial inclusion.

Notes

1. UNCTAD, Afghanistan (2011), Burundi, Rwanda, Tanzania and Uganda (2012); GSMA (2014), Côte d'Ivoire; GSMA (2012), Thailand.
2. mPAY Managing director (2011), Thailand.
3. UNDP, Burkina Faso, Xacbank Mongolia (2011); NAWC, Morocco (2011); CGAP (2012), Senegal.
4. MTN Sustainability report (2011), Benin, Liberia and Zambia; France Telecom Overview of business (2011), Mali.
5. Mobile Money APAC 2012 conference, Mongolia; IFC (2012), Paraguay.

Disclosure statement

No potential conflict of interest was reported by the author.

References

Alexandre, C., I. Mas, and D. Radcliffe. 2010. "Regulating New Banking Models that Can Bring Financial Services to All." *Challenge Magazine* 54 (3): 116–134.

Allan, C., A. B. Jaffe, and I. Sin. 2014. "Diffusion of Green Technology: A Survey." *International Review of Environmental and Resource Economics* 7 (1): 1–33.

Allen, D. 1988. "New Telecommunications Services: Network Externalities and Critical Mass." *Telecommunications Policy* 12 (3): 257–271.

Allen, F., A. Demirgüc-Kunt, L. Klapper, and S. Martínez Pería. 2012. "The Foundations of Financial Inclusion: Understanding Ownership and Use of Formal Accounts." Policy Research Working Paper WPS 6290, Washington, DC: World Bank Group.

Ambrosius, C., and A. Cuecuecha. 2016. "Remittances and the Use of Formal and Informal Financial Services." *World Development* 77: 80–98.

Amidzic, G., A. Massara, and A. Mialou. 2014. "Assessing Countries' Financial Inclusion Standing – A New Composite Index." IMF Working Paper WP/14/36.

Andrés, L., D. Cuberes, M. A. Diouf, and T. Serebrisky. 2010. "Diffusion of the Internet: A Cross-country Analysis." *Telecommunications Policy* 34 (5–6): 323–340.

Antonelli, C. 1991. *The Diffusion of Advanced Telecommunications in Developing Countries*. Paris: OECD. Development Centre Studies.

Anzoategui, D., A. Demirgüç-Kunt, and M. S. Pería. 2014. "Remittances and Financial Inclusion: Evidence from El Salvador." *World Development* 54: 338–349.

Arestoff, F., and B. Venet. 2013. "Learning to Walk Before You Run: Financial Behavior and Mobile Banking in Madagascar." Economics Papers from University Paris Dauphine DT/2013/09.

Beck, T., A. Demirgüç-Kunt, and M. S. Peria. 2008. "Banking Services for Everyone? Barriers to Bank Access and Use Around the World." *The World Bank Economic Review* 22 (3): 397–430.

Becker, K., F. Kronthaler, and K. Wagner. 2011. "The Entrepreneurship Potential Within Swiss Regions: A Comparison Based on Cluster Analysis." In *Entrepreneurship Growth and Economic Development: Frontiers in European Entrepreneurship Research*, edited by M. Raposo, D. Smallbone, K. Balaton, and I. Hortoványi, 180–204. Cheltnham: Edward Elgar.

Berentsen, A. 1998. "Monetary Policy Implications of Digital Money." *Kyklos* 51 (1): 89–117.

Bosire, J. B. 2012. "M-PESA: Why Kenya?" Graduating Extended Essay, Arts and Social Sciences: School for International Studies.

Buku, M., and M. Meredith. 2013. "Safaricom and M-PESA in Kenya: Financial Inclusion and Financial Integrity." *Washington Journal of Law, Technology and Arts* 8 (3): 375.

Camner, G., C. Pulver, and E. Sjoblom. 2010. "What Makes a Successful Mobile Money Implementation? Learnings from M-PESA in Kenya and Tanzania." GSMA – Mobile Money for the Unbanked.

Camner, G., and E. Sjöblom. 2009. *Can the Success of M-Pesa be Repeated? A Review of Implementations in Kenya and Tanzania*. Nairobi: Valuable Bits.

Caselli, F., and W. J. Coleman. 2001. "Cross-country Technology Diffusion: The Case of Computers." *The American Economic Review* 91 (2): 328–335.

Chia, S. C., H. Li, B. Detenber, and W. Lee. 2006. "Mining the Internet Plateau: An Exploration of the Adoption Intention of Non-users in Singapore." *New Media and Society* 8 (4): 589–609.

Chinn, M. D., and R. W. Fairlie. 2006. "The Determinants of the Global Digital Divide: A Cross-country Analysis of Computer and Internet Penetration." Oxford Economic Papers.

Chou, Y., C. Lee, and J. Chung. 2004. "Understanding m-Commerce Payment Systems Through the Analytic Hierarchy Process." *Journal of Business Research* 57: 1423–1430.

Claessens, S. 2006. "Access to Financial Services: A Review of the Issues and Public Policy Objectives." *The World Bank Research Observer* 21 (2): 207–240.

Claessens, S., G. Dobos, D. Klingebiel, and L. Laeven. 2003. "The Growing Importance of Networks in Finance and Its Effects on Competition." In *Innovations in Financial and Economic Networks*, edited by Anna Nagurney, 110–135. Northampton, MA: Edward Elgar.

Comin, D., and B. Hobijn. 2004. "Cross-country Technology Adoption: Making Theory Face the Facts." *Journal of Monetary Economics* 51 (1): 39–83.

Comin, D., and M. Mestieri. 2013. "Technology Diffusion: Measurement, Causes and Consequences." In *Handbook of Economic Growth*, edition 1, volume 2, chapter 2, edited by Philippe Aghion and Steven Durlauf, 565–622, North Holland: Elsevier.

David, P. A. 1975. *Technical Choice, Innovation and Economic Growth*. Cambridge: Cambridge University Press.

Davidson, N., and P. Leishman. 2010. "Incentivizing a Network of Mobile Money Agents", GSM Association.

De Koker, L., and N. Jentzsch. 2013. "Financial Inclusion and Financial Integrity: Aligned Incentives?" *World Development* 44: 267–280.

Demirgüc-Kunt A., and L. Klapper. 2012. *Measuring Financial Inclusion. The Global Findex Database*. Policy Research Working Paper WPS 6025, Washington, DC: World Bank.

Dermish, A., C. Kneiding, P. Leishman, and I. Mas. 2011. "Branchless and Mobile Banking Solutions for the Poor: A Survey of the Literature." *Innovations: Technology, Governance and Globalization* 6 (4): 81–98.
Di Castri, S. 2013. "Enabling Mobile Money Policies in Sri Lanka. The Rise of eZ Cash." GSMA – Mobile Money for the Unbanked.
Di Castri, S., and L. Gidvani. 2014. "Enabling Mobile Money Policies in Tanzania. A 'Test and Learn' Approach Ton Enabling Market-Led Digital Financial Services." GSMA-Mobile Money for the Unbanked.
Donovan, K. 2012. "Mobile Money for Financial Inclusion." *Information and Communications for Development* 61: 61–73.
Evans, D. S., and A. Pirchio. 2015. "An Empirical Examination of Why Mobile Money Schemes Ignite in Some Developing Countries but Flounder in Most." *Review of Network Economics* 3 (4): 397–451.
Everitt, B. S., S. Landau, M. Leese, and D. Stahl. 2011. *Cluster Analysis*. Chichester: John Wiley and Sons.
Feldman, M. P. 1999. "The New Economics of Innovation, Spillovers and Agglomeration: A Review of Empirical Studies." *Economics of Innovation and New Technology* 8: 5–25.
Ferreira, L., and D. B. Hitchcock. 2009. "A Comparison of Hierarchical Methods for Clustering Functional Data." *Communications in Statistics-Simulation and Computation* 38 (9): 1925–1949.
Fin scope. 2009. *Results of a National Survey on Demand, Usage and Access to Financial Services in Uganda*. Kampala: DFID's Financial Sector Deepening Uganda project.
Flaming, M., C. McKay, and M. Pickens. 2011. *Agent Management Toolkit: Building a Viable Network of Branchless Banking Agents*. Technical Guide. Washington, DC: Consultative Group to Assist the Poor (CGAP).
Forman, C., S. M. Greenstein, and A. Goldfard. 2003. "How Did Location Affect Adoption of the Commercial Internet? Global Village, Urban Density, and Industry Composition." NBER Working Paper w9979.
Frenken, K. 2006. "Technological Innovation and Complexity Theory." *Economics of Innovation and New Technology* 15 (2): 137–155.
Geroski, P. A. 2000. "Models of Technology Diffusion." *Research Policy* 29 (4): 603–625.
GSMA. 2015. State of the Industry Report on Mobile Money.
Heyer, A., and I. Mas. 2009. "Seeking Fertile Grounds for Mobile Money." GSMA – Mobile Money for the Unbanked.
Jack, W., and T. Suri. 2011. "Mobile Money: The Economics of M-PESA." NBER Working Paper 16721.
Katz, M. L., and C. Shapiro. 1994. "Systems Competition and Network Effects." *The Journal of Economic Perspectives* 8 (2): 93–115.
Kiyotaki, N., and R. Wright. 1993. "A Search-theoretic Approach to Monetary Economics." *The American Economic Review* 83 (1): 63–77.
Lawack, V. 2013. "Mobile Money, Financial Inclusion and Financial Integrity: The South African Case." *Washington Journal of Law, Technology and Arts* 8 (3): 317.
Liu, M. C., and G. San. 2006. "Social Learning and Digital Divides: A Case Study of Internet Technology Diffusion." *Kyklos* 59 (2): 307–321.
Lyman, T., G. Ivatury, and S. Staschen. 2006. *Use of Agents in Branchless Banking for the Poor: Rewards, Risks, and Regulation*. CGAP focus note 38. Washington, DC: World Bank.
Mansfield, E. 1961. "Technical Change and the Rate of Imitation." *Econometrica* 29: 741–766.
Mas, I. 2009. "The Economics of Branchless Banking." *Innovations* 4 (2): 57–76.
Mas, I., and O. Morawczynski. 2009. "Designing Mobile Money Services Lessons from M-PESA." *Innovations* 4 (2): 77–91.
Mas, I., and D. Radcliffe. 2010. "Scaling Mobile Money." *Journal of Payments Strategy and Systems* 5 (3): 298–315.
Maurer, B. 2011. "AFTERWORD: Mobile Money, Money Magic, Purse Limits and Pins: Tracing Monetary Pragmatics." *Journal of Cultural Economy* 4 (3): 349–359.
Maurer, B. 2012. "Mobile Money: Communication, Consumption and Change in the Payments Space." *Journal of Development Studies* 48 (5): 589–604.
Mbiti, I., and D. Weil. 2011. "Mobile Banking: The Impact of M-Pesa in Kenya." NBER Working Paper 17129.
Mbogo, M. 2010. "The Impact of Mobile Payments on the Success and Growth of Micro Business: The Case of M-Pesa in Kenya." *The Journal of Language, Technology and Entrepreneurship in Africa* 2 (1): 182–203.
McKay, C., and M. Pickens. 2010. *Branchless Banking 2010: Who's Served? At What Price? What's Next?* CGAP focus note 66. Washington, DC: World Bank Group.
Medhi, I., A. Ratan, and K. Toyama. 2009. "Mobile-banking Adoption and Usage by Low-literate, low-income Users in the Developing World." In *Internationalization, Design and Global Development*, 485–494. Berlin: Springer.
Merritt, C. 2011. "Mobile Money Transfer Services: The Next Phase in the Evolution in Person-to-Person Payments." *Journal of Payments Strategy and Systems* 5 (2): 143–160.
Mooi, E., and M. Sarstedt. 2011. *A Concise Guide to Market Research*. Berlin: Springer-Verlag.
Morawczynski, O., and M. Pickens. 2009. *Poor People Using Mobile Financial Services: Observations on Customer Usage and Impact from M-PESA*. CGAP Brief. Washington, DC: World Bank Group.
Ndiwalana, A., O. Morawczynski, and O. Popov. 2010. "Mobile Money Use in Uganda: A Preliminary Study." M4D 2010, 121.
Orléan, A. 2008. "La sociologie économique de la monnaie." In *Traité de sociologie économique*, edited by F. Vatin et P. Steiner, 209–246. Presses Universitaires de France.
Pénicaud, C. 2012. "State of the Industry: Results from the 2012 Global Mobile Money Adoption Survey." GSMA – Mobile Money for the Unbanked.

Pénicaud, C., and A. Katakam. 2013. "State of the Industry (2013): Mobile Financial Services for the Unbanked." GSMA – Mobile Money for the Unbanked.
Pulkki-Brännström, A. M., and P. Stoneman. 2013. "On the Patterns and Determinants of the Global Diffusion of New Technology." *Research Policy* 42 (10): 1768–1779.
Ramji, M. 2009. "Financial Inclusion in Gulbarga: Finding Usage in Access." *New Economics Foundation* 28 (4): 53–76.
Rouvinen, P. 2006. "Diffusion of Digital Mobile Telephony: Are Developing Countries Different?" *Telecommunications Policy* 30 (1): 46–63.
Rysman, M. 2004. "An Empirical Analysis of Payment Card Usage." *Journal of Industrial Economics* 55 (1): 1–36.
Sarma, M. 2008. "Index of Financial Inclusion." Indian Council for Research on International Economic Relations. New Delhi Working Papers, New Delhi, India.
Sarma, M. 2012. "Index of Financial Inclusion – A Measure of Financial Sector Inclusiveness." Berlin Working Papers on Money, Finance, Trade and Development 07/2012.
Sarma, M., and J. Pais. 2011. "Financial Inclusion and Development." *Journal of International Development* 23 (5): 613–628.
Shapiro, C., and H. R. Varian. 2000. "Information Rules: A Strategic Guide to The Network Economy." *The Academy of Management Review* 25 (2): 441–443.
Tobbin, P., and J. Adjei. 2012. "Understanding the Characteristics of Early and Late Adopters of Technology: The Case of Mobile Money." *International Journal of E-Services and Mobile Applications (IJESMA)* 4 (2): 37–54.
Toxopeus, H. S., and R. Lensink. 2007. "Remittances and Financial Inclusion in Development." WIDER Research Paper 2007/49.
Van den Bulte, C. 2000. "New Product Diffusion Acceleration: Measurement and Analysis." *Marketing Science* 19 (4): 366–380.

Appendix 1. Results of alternative procedures of clustering

Table A1.

Nearest neighbour method		*Furthest neighbour method*	
Alternative procedures of clustering 2011			
Cluster 1	LBR-PRY-BFA-BDI-MAR AFG-ZMB-SEN-MNG-COL NGA-SLE-MYS-MLI-BEN IDN-MDG-RWA-UGA	Cluster 1	LBR-PRY-BFA-BDI-MAR AFG-RWA-ZMB-IDN-COL MYS-MLI-NGA-BEN-SLE
Cluster 2	THA-PHL	Cluster 2	MDG-MNG-SEN-UGA
Cluster 3	CIV	Cluster 3	THA-PHL-CIV
Cluster 4	TZA	Cluster 4	TZA
Cluster 5	KEN	Cluster 5	KEN
Alternative procedures of clustering 2014			
Cluster 1	IDN-MWI-TON-NAM-MDG BFA-PHL-LBR-NER-NGA AFG-MAR-GUY-GNB-TGO MYS-BEN-MLI-SEN-ZAR SWZ	Cluster 1	IDN-MWI-TON-NAM-MDG BFA-PHL-LBR-NER-NGA AFG-MAR-GUY-GNB-TGO MYS-BEN
Cluster 2	ZWE-ZMB-FJI-LSO	Cluster 2	MLI-SEN-ZAR-SWZ
Cluster 3	RWA-UGA-KEN	Cluster 3	ZWE-ZMB-FJI-LSO-WSM
Cluster 4	WSM	Cluster 4	RWA-UGA-KEN
Cluster 5	CIV	Cluster 5	CIV
Cluster 6	TZA	Cluster 6	TZA

Appendix 2. VRC and the Duda and Hart Index

Table A2.

	VRC		Duda and Hart Index	
Nb. Of clusters	Calinski Harabasz pseudo-*F*	VRC	Duda Hart Index	Pseudo *T*-square
VRC and the Duda and Hart Index 2011				
2	75.41	…	0.3982	31.74
3	106.27	113.42	0.2882	49.39
4	250.55	**−136.02**	0.4325	19.68
5	258.81	36.18	0.476	**3.30**
6	303.25	36	0.0175	56.06
7	383.69	−6.13	0.4696	10.16
VRC and the Duda and Hart Index 2014				
2	72.81	…	0.2471	73.12
3	96.14	23.77	0.0975	27.76
4	143.24	19.03	0.1807	31.74
5	209.37	**−9.06**	0.2856	37.51
6	266.44	**16.66**	0.0749	**24.70**
7	340.17	77.6	0.1753	**14.11**

Note: Optimal number of clusters are in bold.

Appendix 3

Table A3. One-way ANOVA analysis.

		Sum of square	df	Mean of square	*F*	Sig.
ANOVA 2011						
Adoption level of	Between	6344.2282	4	1586.05705	581.03	0.00
Mobile Money	Within	51.8650355	19	2.72973871		
	Total	6396.09323	23	278.09101		
Service life	Between	44.8706439	4	11.217661	3.26	0.03
	Within	65.3956061	19	3.441874		
	Total	110.26625	23	4.79418478		
ANOVA 2014						
Adoption level of	Between	3826119.71	5	765223.942	266.99	0.00
Mobile Money	Within	71652.7396	25	2866.10959		
	Total	3897772.45	30	129925.748		
Service life	Between	21.925131	5	4.38502621	0.73	0.6
	Within	149.550256	25	5.98201024		
	Total	171.475387	30	5.71584624		