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## **Digital Money: How Ready are Countries to Adopt?**

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### **Abstract**

Digital money has been claimed to have the potential to provide major economic and social benefits, however there is little research into the readiness of countries to adopt digital money. Defined as 'currency exchange by electronic means', we conceptualize digital money as a socio-technical system, and propose a Digital Money Readiness Index. This composite index integrates institutional, financial, technological, economic, industrial and social attributes to measure how ready a country is to adopt digital money. We first outline the digital money system, detailing its interdependent components. We then detail our index construction methodology, listing the indicators selected, and the techniques of normalization, dealing with outliers, weighting, the ranking calculation and clustering techniques. We identify four stages of readiness, Incipient, Emerging, In-Transition and Materially Ready, as well as analyze the relationship of digital money readiness to measures of cashlessness. We conclude with a discussion and future directions.

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## **ABSTRACT**

Digital money has been claimed to have the potential to provide major economic and social benefits, however there is little research into the readiness of countries to adopt digital money. Defined as “currency exchange by electronic means”, we conceptualize digital money as a socio-technical system, and propose a Digital Money Readiness Index. This composite index integrates institutional, financial, technological, economic, industrial and social attributes to measure how ready a country is to adopt digital money. We first outline the digital money system, detailing its interdependent components. We then detail our index construction methodology, listing the indicators selected, and the techniques of normalization, dealing with outliers, weighting, the ranking calculation and clustering techniques. We identify four stages of readiness, Incipient, Emerging, In-Transition and Materially Ready, as well as analyze the relationship of digital money readiness to measures of cashlessness. We conclude with a discussion and future directions.

## INTRODUCTION

Money is one of the most influential factors shaping human history, driving not only wealth creation and socio-economic development, as well as religion, ethics, morality, and fine art (Eagleton & Williams, 2011). Money has a number of purposes in society: it is a unit of account which enables the measurement and recording of value; it is a way to store value for convenient future use; and it is a mechanism of value exchange (Bohannon, 1959; Simmel, 1990). For most of human history, this mechanism of value exchange has been part of the functioning of society. Beginning with barter, this mechanism of exchange was soon replaced by items, better known as money, which acted as proxies for value (Westland, 2002). Thus for those societies close to oceans, sea shells served as proxies of value; in other places special stones, and later on pieces of metal, such as gold and silver, were shaped into coins (Kelly, 1997). The subsequent development of printing led to the development of notes; later still the development of telecommunications, beginning with the telegraph, opened value exchanges through information technology. Today value is exchanged in a variety of ways, ranging from paper and metal coins, through short text messages on mobile phones, near field communication (NFC), to the transfer of data over the internet. Beyond value exchanges of existing currencies, such as the US dollar or British pound, crypto-currencies such as Bitcoin are gaining in popularity, with differing technological variants continually being proposed (see for instance Eslami & Talebi, 2011; Juang, 2007; Peha & Khamitov, 2004).

These new electronic means of value exchange have been variously called electronic money (Singh, 1999), electronic cash (Westland, 2002), e-money (Mbiti & Weil, 2013), and mobile money (Erling, 2013), amongst other names. Each of these labels considers the same phenomenon from differing perspectives. For instance, “mobile money” applies to electronic means of exchange through mobile phones, “electronic cash” to stored-value services, and “electronic money” to the general digitization of currency flows, including direct transfer and credit cards. We take an encompassing view, and collectively call these electronic means of value exchange *digital money*. More precisely, we define digital money as “currency exchange by electronic means”. Thus within our scope are all non-cash and non-paper value exchange transactions such as credit/debit/charge cards and direct

transfer, as well as all value exchange transactions via electronic channels such as ATMs, Electronic Funds at Point of Sale (EFTPOS) and prepaid cards. Also within our scope are new exchange intermediaries such as PayPal and M-PESA, as well as stores of value that can be used for transactions, such as Oystercard, MetroCard, and EZY-Pass. In addition, we include the emerging crypto-currencies and their mechanisms of value exchange. This is a wide scope, but collectively it provides a useful tool with which to consider the totality of continuing process and differing mechanisms of electronic value exchange.

Some have argued that digital money, as distinct to earlier forms of money, has the potential to provide major economic and social benefits. For instance, Dodgson, Gann, Wladawsky-Berger, and George (2012) have argued that the reduction of time lost in making transactions, or waiting for receipt or confirmation of payments, will improve productivity by removing the ‘friction’ in transactions. Others have emphasized the social and economic benefits of mobile payments such as M-PESA in developing nations (Jack & Suri, 2011; Morawczynski, 2014). Digital money also offers the possibility of ‘dis-intermediating’ financial systems through removing the requirements for intermediaries to facilitate transactions (Dodgson et al., 2012). However, there is little literature which systematically analyses these benefits. To date, the most detailed academic attention on money, and to a lesser extent digital money, has come from anthropology (Maurer, 2006; Parry & Bloch, 1989) and history (Eagleton & Williams, 2011; Ferguson, 2012). The research that has specifically covered digital money has generally considered the regulatory and monetary policy implications, mainly with a focus on the ability of the central bank to maintain monetary policy (Rogers, 2006; Woodford, 2000). As such these claims of the benefits of digital money are yet to be rigorously investigated.

It is not our ambition to investigate these claims in this paper; that work shall follow. However, if we accept that there are benefits to digital money, even if they are not well theoretically developed or empirically proven, it becomes important to understand the adoption of digital money. At the country level, all countries have adopted some aspects of digital money, be it credit cards, mobile payments, or e-banking funds transfer. Levels of adoption vary; for instance, in the European context, Snellman, Vesala, and Humphrey (2001) found although there was a trend towards the adoption of

card-based digital money, countries themselves are at significantly different stages of the process. Moreover, not all countries have adopted the same technologies; and those that have adopted the same technologies will not have necessarily implemented it in the same way. This is underpinned by the complex technological, historical, social, political, cultural, religious and ethical aspects of money which drive societal preferences (Eagleton & Williams, 2011; Singh, 1996). For instance, in the developed world, the focus of digital money adoption has been on NFC and stored value cards (such as the Oyster card for the London Underground). In contrast in less developed countries the focus instead has been on mobile payments, such as M-PESA in Kenya. Similarly, in some countries credit cards are used for the majority of day-to-day transactions, while in others they are often used as flexible financial safety nets (Mann, 2006). This makes comparisons between countries problematic, as the same level of monetary digitization in the economy may mask fundamentally different digital money technologies in use, or different usage patterns of the same digital money technology. This difficulty is compounded as new digital money technologies are continually developed and implemented, making the measurement of digital money adoption a moving target.

An alternative approach is to measure the level of cashlessness within an economy, based on the intuition that increasing digitization will result in a cashless society (Snellman et al., 2001; Wolman, 2013). However appealing this notion is, empirically it appears that the use of cash is not necessarily decreasing, even within advanced economies. For instance, Evans, Webster, Colgan, and Murray (2013) demonstrate that the overall real spending in cash is increasing due to economic growth, and that the actual extinction of cash is many generations away. Similarly, Freedman (2000) concludes that it is “extremely unlikely that electronic money will replace bank notes ... that are offered by central banks in the foreseeable future” (p 211). Furthermore, those attempts to measure cashlessness have focused on consumer spending, and hence only captures part of the digital money technologies in use (see for instance Dave & Baxter, 2013; Thomas, Jain, & Angus, 2013). As a consequence, measures of cashlessness only partially capture the adoption of digital money within an economy.

Rather than consider a measure of digital money adoption which may mask important differences within a country or omit specific digital money technologies, a more promising measure is that of the *readiness* of a country to adopt digital money. By readiness we mean the level of development of the country with respect to the institutional, financial, technological, and economic factors that underpin digital money. For instance, there is a minimum level of financial regulation and information and communication technology (ICT) infrastructure required for digital money. Moreover, differing innovation, business and political environments will influence the ability and the willingness of merchants to utilize and consumers to adopt digital money. As a consequence, different countries will have differing levels of readiness for digital money adoption based off their institutional, technological, business and social attributes, and these attributes provide insight into which digital money technologies would be adopted, as well as how that specific technology would be adopted. As these attributes drive digital money adoption, it is possible to avoid having to monitor the adoption of particular digital money technologies within a particular economy. For instance, in more developed countries, with greater credit card and smartphone penetration, the diffusion of NFC technologies would influence adoption patterns, while in less developed countries mobile payments would be more prevalent. By focusing on institutional, financial, technological, and economic factors within countries, both developed and less developed countries, as well as the differing digital money technologies, are able to be measured. Although this measure does not consider digital money adoption directly, we suspect that it correlates with digital money adoption measures, such as levels of cashlessness.

To provide better insight into the differing readiness of countries for digital money, we propose a Digital Money Readiness Index. This composite index integrates a selection of institutional, financial, technological, economic, industrial and social attributes that measure how ready a country is to adopt digital money. Composite indices such as these are increasingly recognized as a useful tool in policy analysis, public communication and corporate strategy (OECD, 2007). To build the index we theoretically model digital money as socio-technical system which consists of a number of interacting and interdependent components. This systemic approach is given more salience by the fact that digital

money is underpinned by platform technologies that coordinate multi-sided markets (Evans, Hagi, & Schmalensee, 2006; Rochet & Tirole, 2002, 2006). Adopting the diamond model structure of Porter (1990), we suggest that there are four main components to the digital money system in any particular country: the institutional environment, the enabling infrastructure, supply and demand. Taking these four components as the pillars of the composite index, we select a range of indicators which measure progress along each pillar, clearly detail our methodology, rank countries on their digital money readiness, and, using cluster analysis, identify four stages of readiness.

We are not the first to consider the readiness of a country for the adoption of digital money. Looking instead at the reduction in the amount of cash in an economy, previous efforts comprise the MasterCard Cashlessness Readiness Index (Thomas et al., 2013) and the Market Platform Dynamics Cash-at-Risk Index (Evans et al., 2013). We differ to these earlier measures by taking an academic approach to the challenge of measuring readiness, both by expounding the theoretical basis for our measure of readiness, as well as transparently detailing our methodology and data sources. Moreover, in contrast to these two measures, it is our goal to develop a transparent country-level view of the factors that hinder (i.e., the bottlenecks) and help each country's readiness score, with a view to providing a roadmap to becoming more ready for digital money over time. However, these two measures provide a valuable cross-check on the robustness of our index – if our index has a good correlation with these indices then we can be confident that our index is aligned with the thinking of others.

Given that we are measuring digital money readiness as distinct to adoption, we also investigate how our measurement digital money readiness relates to existing measures of cashlessness. Based on the intuition that the level of cashlessness in an economy is a proxy for the adoption of digital money, we compare the index with the MasterCard Cashlessness Score (Thomas et al., 2013), as well as with a more general measure called Cashless Intensity, developed by Citigroup (Dave & Baxter, 2013). As well as testing the accuracy of our assertion that there is strong correlation between readiness and adoption, this analysis provides insight into whether digital money readiness actually translates into adoption, and begins a deeper analysis of the factors that enable and constrain digital money adoption.

The paper is structured as follows. In the next section, we outline a digital money system, detailing its interdependent components. We detail index construction, listing the indicators selected for each pillar, and the techniques of normalization, dealing with outliers, weighting, ranking calculation and clustering. We then review country rankings and groupings, before analyzing our index with measures of cashlessness in society. We conclude with a discussion and future directions.

## **THE DIGITAL MONEY ECOSYSTEM**

From its earliest conceptualizations, scholars have discussed money and means of value exchange as a system (Eagleton & Williams, 2011). Indeed, the modern monetary regime is generally called the ‘monetary system’ (Mbiti & Weil, 2013; Rogers, 2006; Woodford, 2000). We consider money to be a socio-technical system. Although the notion of the socio-technical system was first proposed in the context of labor studies (Emery & Trist, 1960), we take a more societal approach to consider money as a socio-technical system that encompasses production, diffusion and the use of a technology, that fulfils societal functions (Geels, 2004). Thus, the monetary socio-technical system consists of technology, regulation, user practices, markets, cultural meaning, infrastructure, production, and supply networks. Socio-technical systems have substantial inertia, driven by path-dependence and lock-in (Arthur, 1994; David, 1985). This inertia is driven by rules and regulatory regimes that provide stability though guiding perceptions and actions, mutual dependence between actors driven by their embeddedness in the system, and also complementarities between technical components that make radical systemic change difficult (Dosi, 1982; Geels, 2004). This means that innovation and change is often incremental within a given socio-technical system (Geels & Kemp, 2007).

In the case of digital money, taking a socio-technical systemic approach is even more persuasive, as not only is there as socio-technical system of value interchange as commonly understood, but digital money also relies on information and communication technologies that are themselves systems. As a consequence, digital money research into mobile money and payments takes a technological systemic approach (Kent, 2012; Mbiti & Weil, 2013; Rochet & Tirole, 2002), as does research into crypto-currencies (Eslami & Talebi, 2011; Juang, 2007). Some scholars have integrated

both the technical and broader performance aspects of systems, detailing relevant technical characteristics of a digital money system, such as identify-ability of transactions, scalability and consistency, and interoperability, as well as more traditional concerns such as vulnerability, reliability and durability and cost (Misra, Javalgi, & Scherer, 2004).

As a socio-technical system where there are varied and multiple participants that use shared core technologies, the digital money system also involves network effects, multisided markets and platforms. Network effects occur when the use of a good or service by one user has an influence on the value of that product to other people. In digital money systems, network effects have important implications for the adoption of new currencies and of digital money technologies, as well as competition between different currencies and monetary technologies. For instance, positive network effects can result in rapid adoption of a currency or technology as increasing supply leads to increased demand. Put differently, consumers must be able to easily obtain digital money as well as have plenty of opportunities to spend it (Kelly, 1997). Similarly, network effects can result in complex competitive dynamics involving interchange, compatibility and standardization (Katz & Shapiro, 1994). Multi-sided markets occur when there are multiple distinct user groups or markets that provide each other with network benefits, and are coordinated through platforms (Rochet & Tirole, 2006). Indeed, the seminal paper that econometrically modelled multisided markets studied the effects of the no-surcharge and interchange fees in the credit card providers market (Rochet & Tirole, 2002). The multisided nature of digital money often results in difficulties in adoption, as both the merchant and the consumer must have the means with which to transact (Caillaud & Jullien, 2003).

As a consequence, it is no surprise that some scholars have adopted the notion of the “ecosystem” (see for instance Erling, 2013; Kemp, 2013; Kent, 2012), considering the digital money system to be a network of participants in which value is co-created amongst multiple co-specialized participants (Autio & Thomas, 2014). For instance, Kemp (2013) identifies six interdependent set of market participants in a digital money ecosystem: card schemes, mobile operators, retailers, device suppliers, service providers, as well as trusted service providers that manage the range of contractual and technical connections between the participants. Although Kemp specifically considers mobile

payments, his identification of multiple market participants who are mutually dependent on each other, who interact through platforms that are typified by multisided markets, demonstrates the systemic nature of digital money generally.

Kemp furthermore identifies the importance of regulation in governing the interactions within the ecosystem, an important element of any socio-technical system (Geels, 2004; Geels & Kemp, 2007). Regulatory concerns relate to both the ability of the central bank to oversee the monetary system (Freedman, 2000; Lee & Longe-Akindemowo, 1999; Rogers, 2006), as well as privacy and security concerns (Kelly, 1997; Roberds, 1998). These regulations can both support as well as hinder digital money adoption. For instance, in 2000 the European Union (EU) passed its First E-Money Directive which was meant to enable the supply of digital money in the EU member states by creating legal certainty, avoid hampering technological innovation, preserve a level playing field, and ensure the stability and soundness of digital money (Halpin & Moore, 2009). The importance of regulation was emphasized by the many difficulties that this Directive caused, which in fact actually slowed the development of digital money in the EU (Courtneidge, 2012).

Given its socio-technical systemic nature and the importance of regulation to digital money, we have conceptualized the digital money system adopting the diamond model of Porter (1990). Although Porter's diamond model was developed to explain the competitive advantages of nations, it aligns with existing theorizations of socio-technical systems (Geels, 2004). It incorporates supply and demand conditions as important factors which drive system performance, which also capture well the multi-sided relationships that typify the relationship between consumers and merchants in digital money contexts. In particular, the provider's supply of digital money can hasten the pace of adoption of digital money, as can the demand driven by the motivations of the user (Singh, 1999). Similarly, the diamond model incorporates a focus on relating and supporting industries, which are also important in digital money contexts – both from the perspective of the underlying technological regime (Dosi, 1982; Kim, 2003) that enables digital money, but also the regulatory context that digital money operates within. Finally, the diamond model also considers the role of the institutional

environment, specifically the actions of government, which can influence supply and demand conditions, as well as the provision, quality and accessibility of the enabling infrastructure.

As such, we propose four interacting components that compose the digital money socio-technical system: the national institutional context, the enabling technological and financial infrastructure, the demand for digital money, and the industries that drive digital money supply. We now discuss each in turn.

### **Institutional environment**

The institutional environment comprises the national institutional characteristics within which digital money needs to operate. One institutional requirement for digital money is an adequate rule of law and the quality of the regulations. Key to any digital money system is trust – as commanding confidence in money and payments is vital given the natural inertia that typifies money systems (Cohen, 2000). This requirement for trust becomes more salient due to the intangibility of digital money. Thus, to engender confidence in digital money, as well as regulations that are stable and long lasting, digital money requires an adequate level of law abidance in particular in relation to contract enforcement and property rights. Indeed, merchants, consumers and other financial intermediaries want to make sure that their digital money cannot be easily appropriated by others (Kelly, 1997). Furthermore, the move to digital money can open up new opportunities for fraud which consumers, merchants, intermediaries and banks want to be protected against (Roberds, 1998). Relatedly, the legal environment needs to ensure privacy and security, as consumers want to keep the value of their consumption private, and merchants and intermediaries want to ensure they capture an appropriate record of their sale (Kelly, 1997).

Beyond the legal environment, the institutional economic factors also influence digital money. For instance, those countries that have efficient markets are well positioned to ensure that there is effective trade between organizations (Williamson, 1975), and hence an institutional environment conducive to digital money technologies. Similarly, healthy market competition drives business productivity by ensuring that the most efficient firms are those that thrive (Smith, 1994), further providing the conditions for the adoption of digital money technologies. As a consequence, an

efficient market is likely to encourage regulators, government, organizations and consumers alike to adopt digital money, so that the institutional environment assists in overcoming the natural inertia of monetary change. In contrast, in those economies with inefficient markets, there will be little appreciation of, or need for, either by consumers or providers of digital money, and hence little likelihood of overcoming the inertia.

Another national institutional characteristic is the innovation environment. Innovation has been at the core of many historical productivity gains, not only transforming the way things are done, but also opening a wider range of new possibilities in terms of products and services (Dodgson, Gann, & Salter, 2008). Thus the nature and rate of innovation within an economy will influence the economic environment within which digital money will be provided and consumed, including the type of digital money offered. For instance, innovative economies will develop a greater variety of innovative digital money technologies, which may assist in overcoming the natural inertia of monetary change. However, in those economies that are not considered innovative, there is less likelihood that digital money innovations will emerge that overcome the inertia.

### **Enabling infrastructure**

The enabling technological and financial infrastructure comprises the technological development and financial regulatory characteristics that underpins the deployment and operation of digital money technologies.

The technological enabling infrastructure covers the provision, availability and affordability of information and communication technologies within a country. For instance, the levels of electricity, mobile network coverage, and broadband provision influence how ready a country is to adopt digital money – when mobile network coverage is good, but broadband provision poor, digital money technologies based upon mobile devices are more feasible. Similarly, if access to the internet, smartphones or mobility telephony is costly in relation to the average wage, then the infrastructure becomes less available for both companies and individuals to access. In doing so this reduces the readiness of a country for digital money adoption. An economy also needs a population with the skills to be able to use these technologies; if the population is not educated on how to use ICTs, then not

only will the adoption of digital money be hindered through low consumer adoption, but there will be less skilled staff able to support the provision of digital money solutions. As a consequence, the development of the ICT infrastructure is an important enabling characteristic for digital money.

The financial regulatory characteristics within an economy also influence digital money adoption. Different regulatory regimes reflect differing trade-offs between the efficiency of the financial system and the amount of risk assumed by the public sector (Lee & Longe-Akindemowo, 1999). Most digital money regulation has been on reducing systemic risk and increasing the efficiency of the provision of payments services (Singh, 1999). These regulations directly affect the performance of a digital money system, in their efforts to head off the potential systemic risk issues that would occur with the collapse of an electronic payment system (Lee & Longe-Akindemowo, 1999). The financial regulation within a country is related to the level of development of the overall financial market development. Thus the differing availability and affordability of financial services, the function of equity market, soundness of banks, access to loans and venture capital dynamics within any digital money system will influence the types, scope and enforcement of regulations that are in place. However, regulations can also have the effect of limiting newer participants into the digital money system, restricting activity to banks and other established financial intermediaries.

### **Supply conditions**

The supply conditions for digital money comprises the provision of solutions that drive the supply of digital money within an economy. These supply conditions consist of the specialized resources required for the performance of the digital money socio-technical system, which are often specific to an industry. For instance, the sensors required for payment on transit systems are often quite different to those in retail environments. Empirically, scholars have found that the levels of adoption of digital money depends crucially on the provision and diffusion of digital money infrastructure, such as card payment terminals (Snellman et al., 2001).

Supply conditions are best considered from the perspective of the industries that have the potential to implement digital money, and best reap the benefits. For instance, the banking industry has been an early innovator in digital money, introducing many of the digital money technologies

such as credit cards and electronic payments. For the banking industry, digital money provided a means to improve the efficiency and effectiveness of their own operations, as well as encourage the growth of credit products to drive their revenue. Similarly the rise of the internet and the move of commerce to the internet has resulted in increasing provision of digital money solutions to improve efficiency (Panurach, 1996). The increasing levels of government services online has also lead to increasing provision of digital money solutions, as government seeks to improve service delivery, capture tax revenues, and reduce fraud and the cost of benefit disbursements. Other industries which are driving the provision of digital money solutions include the transport industry, such as those services automating payment in metro systems and on toll-roads. Here the provision of digital money enables costs reductions in toll and fare collection, as well as improved insight into the behaviors of consumers.

### **Demand conditions**

Demand conditions comprise the propensity to adopt digital money of consumers and business. The ability to substitute one mechanism of currency exchange depends importantly on the consumers, both individuals and businesses, whose use of digital money is influenced by social, cultural and technological factors (Snellman et al., 2001). As such the demand conditions drives digital money readiness, as businesses and consumers pressure suppliers to innovate faster and to create more advanced offerings.

At a broad level, the propensity to adopt is influenced by the rate at which technology diffuses through an economy (Rogers, 2003). As digital money is a collection of emerging technological forms of currency exchange, the readiness of a country for digital money will be influenced by the rate at which both businesses and individuals accept technological change. For instance, the levels of ‘newness’ and hence perceived riskiness of digital money may lead to slower adoption. Focusing on digital money adoption amongst consumers in Taiwan, some scholars have suggested that the perceived risk of the new technologies lowers the likelihood of adoption (Tu, Hsin, & Chiu, 2011). However emphasizing that cultural and social factors are important in assessing the propensity to

adopt, others scholars have found that in Indonesia risk and security do not reduce the likelihood of adoption (Miliani, Purwanegara, & Indriani, 2013).

Beyond rates of technological diffusion within an economy, digital money also should be easy to use. To function as an adequate substitute for existing payment mechanisms, digital money must have widespread acceptance and fit seamlessly in its users daily activities (Singh, 1999). In particular, the perceived usefulness and ease-of-use have a significant positive effect on likelihood of adoption of digital money, especially in stored-value cards (Singh, 1999), while the perceived cost alone does not reduce the likelihood of adoption (Tu et al., 2011).

## INDEX CONSTRUCTION

Our definition of digital money implies that the measurement of digital money readiness is not a simple task. Indeed, the existence of multiple interacting components that are expressed through different technologies means that digital money readiness is not a clearly defined object of study. Instead, digital money readiness is a multi-dimensional construct. Multi-dimensional concepts which cannot be captured by a single variable, such as competitiveness, industrialization, sustainability, single market integration, or knowledge-based society, are generally measured by composite indices (OECD, 2007). Thus in order to measure the readiness of a country to adopt digital money, we require a composite index. Composite indices are constructed when the goal is to measure something that none of the individual components alone does a good job of measuring (Trochim & Donnelly, 2008).

### Indicators

Building upon the four components of the digital money system – institutional environment, enabling infrastructure, supply and demand – we have selected a variety of indicators which measure the readiness of a country, with each pillar having a number of indicators. The indicators for each pillar are detailed in Table 1.

[Insert Table 1 around here]

**Institutional Environment Pillar.** There are four indicators for the Institutional Environment Pillar. The first indicator considers the Rule of Law, and is measured by the Rule of Law Indicator in

the 2012 Worldwide Governance Indicators of the World Bank. This indicator measures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. A second indicator, also from 2012 Worldwide Governance Indicators of the World Bank, is the Regulatory Quality Indicator which measures the perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Together these two indicators measure the legal environment within which digital money operates. A further indicator considers the Market Efficiency of the economy; we use the Goods Market Efficiency Pillar (Pillar 6) of the World Economic Forum 2013 Global Competitiveness Report. This measures the levels of market competition, both domestic and foreign, which influences business productivity, by ensuring that the most efficient firms, producing goods demanded by the market, are those that thrive. A final indicator is the Innovation Environment, and we use the Innovation Pillar (Pillar 12) of the World Economic Forum 2013 Global Competitiveness Report. This indicator measures the capacity for innovation in a country, including quality of scientific research, company spending on R&D, patents, and government procurement of advanced technology. These two latter indicators measure the wider business and innovation institutional environment within which digital money operates, both of which provide the boundaries of the institutional enablers and inhibitors within any particular economy.

**Enabling Infrastructure Pillar.** Three indicators comprise the Enabling Infrastructure Pillar. The first indicator considers the flexibility of the financial regulators, and is measured by the Financial Restrictions Indicator in the 2011 World Bank surveys on Bank Regulation. This indicator measures the overall restrictions on banking activities in a country, and acts as proxy for the restrictiveness of the regulators, as regulatory flexibility is required for successful adoption of digital money. Where data was not present in the 2011 survey, the most recent data from one of the previous years (1999, 2003 or 2007) was used. A second indicator considers the financial market development, and is measured by the Financial Market Development Pillar (Pillar 8) from the World Economic Forum 2013 Global Competitiveness Report. This pillar measures the availability and affordability of

financial services, as well as function of equity market, soundness of banks, and access to loans and venture capital. As such it reflects the enabling financial infrastructure within a country required for digital money adoption. A final indicator is readiness of the overall ICT infrastructure (“ICT Readiness”), and is measured by the ICT Readiness Sub-Index from the World Economic Forum 2013 Global Information Technology Report. This measures the degree to which a society has an affordable ICT infrastructure and the skills to use it, and hence represents the ICT enabling infrastructure required for digital money adoption.

**Supply Pillar.** We have used five indicators for the Supply Pillar to assess the provision of digital money solutions in the economy. For this pillar we have developed indicators which measure the development of those industries which drive digital supply. The first indicator considers the development of the payments industry, and is measured through the Electronic Payments variable included in the 2013 Global Financial Inclusion Database, released by the World Bank. This variable measures the proportion of population that have made an electronic payment, and acts as a proxy for the provision of digital money services (supply) as increasing levels of electronic payments suggest greater number of services offering electronic payments. A second indicator considers the development of e-commerce, and is measured by the percentage of online retail sales as determined by Euromonitor in 2012. This indicator acts as a measure of digital money supply as the greater the amount of online shopping the greater the likelihood of digital money services to support this online activity. The third and fourth indicators consider the transport industry, in particular the low payment transit systems and toll-ways, as these systems often adopt systems of stored value to automate fare and toll collection. As such they act as indicators of the supply of digital services within an economy. The data for the transit transport indicator is taken from the Wikipedia 2013 List of Metro Systems page,<sup>1</sup> while the data for the toll-ways indicator is taken from the Global List of Toll Operations as determined by the International Bridge, Tunnel and Turnpike Association in 2013.<sup>2</sup> The final indicator considers the level of e-government in an economy, as greater supply of e-government

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<sup>1</sup> [http://en.wikipedia.org/wiki/List\\_of\\_metro\\_systems](http://en.wikipedia.org/wiki/List_of_metro_systems), retrieved 10<sup>th</sup> November 2013.

<sup>2</sup> <http://www.ibtta.org/Information/>; retrieved 14<sup>th</sup> November, 2013.

services increases the likelihood of the provision of digital money services. This is measured by the Index of online services delivery from the E-Government Development Index 2013 released by the United Nations.

**Demand Pillar.** There are four indicators for the Demand Pillar, which looks to the propensity to adopt digital money by businesses and individuals. The Business Sophistication Pillar (Pillar 11) of the World Economic Forum 2013 Global Competitiveness Report measures the quality of the business networks and the quality of individuals firms' operations and strategies. This indicator considers demand from the perspective of businesses in the economy, in that the more sophisticated a business the more likely it is to adopt digital money. The Availability of Latest Technologies Indicator is taken from the World Economic Forum 2013 Global Competitiveness Report, and measures the rate at which the latest technologies become available in an economy. This indicator measures demand for digital money by acting as a proxy for the likelihood of adoption of new technologies. The Levels of Corruption Indicator is taken from the Corruption Score detailed in Corruption Perception Index 2012 released by Transparency International. This measures the perceived levels of public sector corruption in countries around the world, as higher levels of corruption require more untraceable cash, and hence lowers the propensity to adopt digital money. The final indicator is ICT Penetration, taken from the ICT Usage Sub-Index of the World Economic Forum 2013 Global Information Technology Report. This measures individual, business, and government usage of ICTs in their day-to-day activities. This acts as a demand indicator as the greater the use of ICT, the greater the propensity for the adoption of digital money.

The following table presents the correlations between each of these indicators.

[Insert Table 2 around here]

There are moderate to high correlations (both positive and negative) of all indicators. This suggest that all those indicators are measuring a similar underlying phenomenon, catching slightly different perspectives on that phenomenon. Some level of correlation is required if there is to be explanatory power in the combination of the indicators (OECD, 2007). If there was poor or no correlation between these indicators, it is unlikely that they would be able to be combined to suggest a

progression of different readiness states. Some of these indicators are themselves composite indices. To ensure that there is no double counting of a particular data source, each composite index was compared against the others to ensure that a data source within each indicator was not present on one of the other indicators.

## **Methodology**

A composite index is a score – a numerical value – that measures something; as such it necessitates a calculation to create the final ranking of countries. To construct a composite index and derive a quantitative score for a multi-dimensional construct, a set of rules is essential to combine the two or more variables to reflect the more general construct (Trochim & Donnelly, 2008). As composite indices are a combination of different variables, the variables being combined are often measured in different ways and on different scales. Techniques such as normalization and controlling for outliers are required to ensure that indicators can be meaningfully combined. We also further analyze the ranking using clustering, to determine if there are groups of countries within the ranking of countries. We now detail our normalization, dealing with outliers, weighting, ranking calculation, and clustering techniques.

**Normalization.** In terms of normalization, indicators we have selected in the section above have different scales and magnitudes. For this reason we transform all indicators into z-scores, where each indicator has its mean set to zero and a variance of 1.

**Outliers.** Index building is based upon a benchmarking principle, and the selection of the proper benchmark considerably influences the index scores and hence the ranking of the countries. However within some data sets there are outliers that can skew the results so as to create benchmarks that are inappropriate (Szerb, Acs, Autio, Ortega-Argiles, & Komlosi, 2013). We have taken a capping approach, where the outliers are capped at particular values. Although this limits the outlier values, it leaves outstanding the value of cap. Following Szerb et al. (2013), we have capped outliers at the 95% percentile.

**Weighting.** We use principal component analysis to weigh the results. Principal component analysis is a statistical procedure that converts a set of observations (indicators) of possibly correlated variables into a set of linearly uncorrelated variables (Husson, Lê, & Pagès, 2011). Each linearly uncorrelated variable is called a “principal component”. This transformation is done in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible). The advantage of using principal components in aggregating indicators is that the statistical procedure closely matches the theoretical underpinning of index building. As each factor identified by principal component analysis represents a certain proportion of the total variance, with the first factor representing the largest proportion of the variance, we use the first factor as the source of the weighting.

Weightings were applied at two stages. We first adjusted the individual impact of an indicator on a pillar. Following the application of the weighting within pillar, we normalize each pillar score again before using principal component analysis again to determine the weight of each pillar. Table 3 below outlines the weightings applied at both the indicator and pillar levels.

[Insert Table 3 around here]

**Ranking calculation.** The final ranking is obtained as a weighted average of the pillars’ scores. This means that every country that scores above zero is above the average of the sample of countries, while every country with negative scores is below the average of the sample countries. The greater their absolute score the further a country is from the average. As a consequence our ranking is a relative ranking where countries are positioned in relation to each other. This implies that adding or removing countries from the sample will modify the score of all the countries (but not the order of the ranking).

This ranking is the first and maybe the more visible outcome of the index, as it lists countries in their order of readiness for digital money. However, there is another outcome of the index that should prove more relevant for policy. Based on the principal components used to determine the weightings of each pillar for an individual country, we can distinguish groups of countries that have achieved similar level of maturity. Doing so allows us to look at difference between groups to establish a

description of the current level of maturity in each group, highlighting the main differences between groups.

**Clustering.** The natural methodology to group countries within the ranking is clustering. Although many algorithms can be used to cluster countries, we have applied hierarchical clustering (Kaufman & Rousseeuw, 1990), which has the advantage of being well integrated with principal component analysis procedures. To cluster the results, we utilize the first two factors identified by the principal component analysis conducted at the pillar level. This allows us to distinguish four groups of countries with regard to their performance on the index. Each cluster is described according to their score on each pillar, as presented in Table 4.<sup>3</sup>

[Insert Table 4 around here]

At the two extremities, there are countries that score high on each pillar (Cluster 4), and incipient countries that score low on all pillars (Cluster 1). In the middle, there are two clusters that are close together: one cluster that does well on some of the indicators but in which on aggregate countries scores are below average (Cluster 2), and a second cluster (Cluster 3) that is above average on aggregate but are trailing behind Cluster 4 on some indicators. Clusters 2 and 3 are characterized by differences in their institutional environment, and supply and demand conditions. Thus countries within Cluster 2 are slightly below average on pillar 1, 3 and 4, and Cluster 3 countries are slightly above average on those same pillars.

### **Robustness**

For robustness, we have compared the Index with the MasterCard Cashlessness Readiness Index (Thomas et al., 2013) and the Market Platform Dynamics Case-at-Risk Index (Evans et al., 2013). As these indicators have less extensive coverage than our index, we limit the comparison to the countries that feature in their studies. There is a strong correlation with the MasterCard Cashlessness Readiness Index (0.97), as well as quite a strong correlation (0.74) with the Market Platform

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<sup>3</sup> The pillars are ordered in their importance to the cluster description.

Dynamics Case-at-Risk Index. Taken together, these correlations suggest that our Digital Money Readiness Index is congruent with similar thinking for readiness for cashlessness.

## **DIGITAL MONEY READINESS**

Figure 4 shows the digital money readiness ranking for 2013, with the countries grouped by cluster.<sup>4</sup>

[Insert Figure 3 around here]

As can be seen in Figure 3, and as described above, the clustering analysis identified four groups of countries. We have named these clusters the Incipient, Emergence, In-transition and Materially Ready stages. In the Incipient stage, countries are often characterized by a lack of affordable (and basic) ICT infrastructure and expensive and/or limited financial services. For countries in the Emerging Stage, the basic ICT infrastructure and financial services are in place, and the relevant regulation is on the books. Here the challenges tend to be one or more of the following: the presence and size of the informal economy; (perceived) lack of enforcement of existing regulation, both for consumers and corporates; lack of ICT ubiquity and affordability; and consumer preference for cash. For countries in the In-Transition stage, the challenges of the Incipient and Emerging stages have been largely resolved. Often, these countries have successfully deployed accelerators such as social disbursements. However they still may need to make investments in to drive digital money supply, such as digital payments for transit or the seeding of e-commerce initiatives. Sometimes, it may be a matter of lowering restrictions on financial investments so that a healthy system of private enterprises can take root. Finally, countries in the Materially Ready stage are characterized by ubiquitous ICT diffusion coupled with familiarity of digital solutions. They also exhibit a market friendly business and regulatory environment that facilitates private sector investment and innovation in digitally enabled solutions.

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<sup>4</sup> For the full listing, please contact the authors. It has been removed from the paper due to space constraints.

These readiness stages provide a useful perspective to interpret the result of the index. In particular, they provide the basis for broad policy specifications. As each readiness stage can be characterized according to the mean score of the countries in the group on each pillar, they can serve as the basis to outline what is required for a transition from one stage to the next (see Table 5). For example, the Incipient countries have the lowest score on all of the pillars. When compared to the next readiness stage, Emergent, one can see that overall, the Emergent countries score higher on all pillars, but still significantly less than the average of the whole sample, except for one pillar. For Pillar 2, financial and technological infrastructure, the Emergent countries are scoring close to the average level of the sample of countries. This implies that a policy focus on improving the financial and technological infrastructure is likely to lead to a transition between the Incipient and Emerging stages.

The policy considerations for a transition between the Emergent to the In-Transition stage is driven by the finding that countries in the In-Transition stage score higher than countries in the Emergent stage on all pillars except for the financial and technological infrastructure pillar (Pillar 2), where the result is not significant ( $p < 0.05$ ). This suggests that policy focus should move to the improvement of supply and demand conditions (Pillars 2 and 3) – solution provision and the propensity to adopt respectively. Policy makers should particularly focus on encouraging demand, as this drives the identification of the In-Transition group. As progress on the supply and demand conditions would be difficult to achieve without both the appropriate institutional environment and financial and technological infrastructure, a country should also continue to develop these. Indeed, the level of development of the financial and technological infrastructure will limit the scope of digital money solutions possible and therefore the opportunity for citizens to want to adopt. This is not to say that digital money technologies cannot be provided in countries that score low on financial and technological infrastructure, but that those solutions will be limited in scope and very likely to be incompatible with exchange on the global market (such as M-PESA).

The policy considerations for a transition from In-Transition to Materially Ready is driven by the finding that there is an increase on the score for each pillar. However the main difference between the two stages is that Materially Ready countries have enabling financial and technological

infrastructure (Pillar 2) that is significantly more advanced.<sup>5</sup> This again hints toward a need for policy focus to shift again to the infrastructure after sufficient progress has been made on the other pillars.

Summarizing, four stages can be observed within the ranking of digital money readiness – Incipient, Emerging, In-Transition and Materially Ready. These stages point to a need for policy to be flexible and attuned to the progress achieved by each individual country. Policy recommendations can be further tailored by examining an individual country’s position among countries in the same readiness stage and countries in the following stage of readiness to help identify where policy is the most likely to have the most beneficial effects.

### **RELATIONSHIP TO CASHLESSNESS**

Given that many of these electronic monetary exchange mechanisms have been occurring since the 1950s between organizations, and the credit card enabled digital money transactions to consumers, the increasing use of digital money has often been considered alongside the reduction of cash within economies. The rise of debit and credit cards, and the concomitant reduction in cash and checks, has often been seen as indicative of the move to a cashless society (see for instance Snellman et al., 2001). Indeed, since the advent of credit cards and electronic funds transfer, some commentators have been predicting not whether cash would disappear, but when (Evans et al., 2013; Wolman, 2013).

However, others have pointed out that the use of cash is not necessarily decreasing. For instance Erling (2013) has argued that a cashless society is not imminent, as there will always be demand for means of exchange that is anonymous, without question accepted as legal tender, and if it does not pass through a bank account, cannot be traced and not taxed. Certainly, all cash usage is not for nefarious reasons, but for many consumers physical cash will remain the dominant payment mechanism. Similarly, Evans et al. (2013) point out that although cash is declining in many countries, the real spending in cash is increasing due to economic growth. They conclude that although it is inevitable that physical money usage will eventually decrease, the actual demise of cash is many generations away. From a monetary policy perspective, Freedman (2000) also concluded the same,

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<sup>5</sup> This serves to emphasize the importance of continuing a focus on the enabling conditions in the Emerging to In-Transition change.

noting that it is “extremely unlikely that electronic money will replace bank notes or the settlement services that are offered by central banks in the foreseeable future” (p 211).

As such it is of interest to see how levels of digital money readiness relate to levels of cashlessness in an economy. We have correlated our index with two measures of cashlessness. The first measure of cashlessness we compare with is the Citi Cash Intensity Ranking and the MasterCard Cashless Index. The former is measured by dividing the consumer spending using credit, debit, charge or prepaid cards by the total consumer expenditure. Although this lacks such data on new exchange intermediaries such as PayPal, M-PESA, etc. (which impacts countries like Kenya) and on ‘stores of value’ (such as Oyster card, which may impact the ranking of countries like UK and Singapore) in the numerator, this simple measure captures the proportion of non-cash utilized in consumer exchanges in an economy. The latter measure focuses on consumer payments, measuring non-cash payments as a share of the total value of consumer payments (Thomas et al., 2013). Figure 5 presents the scatterplots of these comparisons.

[Insert Figure 5 around here]

The correlation with Cashless Intensity index is 0.79, and 0.84 with the MasterCard Cashless Index. These correlations between our index and measures of cashlessness go some way to indicate that there is a relationship between readiness and adoption. They also further indirectly provide a robustness check.

This imperfect correlation also points to one advantage of our methodology over a coarser approach: using multiple indicators allows insight into the factors that drive digital money adoption, and hence enables analysis and an identification of factors that are not (yet) captured by our index. For example, both Japan and Germany are in the Materially Ready stage according to our index despite both having a high cash intensity. This is due to the fact that there is a cultural preference for cash in Germany, as well as a proliferation of infrastructure for handling cash, leading to increased inertia. In the case of Japan, there is a cultural bias against liabilities (and hence credit products), which results in a preference for cash. Furthermore, Japan has high interchange rates on credit cards which also reduces the usage of card within the economy. As a further example, both Argentina and

Venezuela appear to have lower cash intensity than their readiness score would indicate. In the case of Argentina, there has been active government encouragement of digital money adoption, primarily to improve tax collection. This analysis suggests that Germany and Japan are in a much better position to adopt digital money than other countries with lower cash intensity, and that Argentina and Venezuela have probably reached the limit of their digital money adoption, given their current levels of readiness.

## **DISCUSSION AND FUTURE DIRECTIONS**

We have developed a perspective of the digital money as a socio-technical system, using the diamond model of Porter (1990). This permits the identification of four interdependent components: the institutional environment, enabling infrastructure, supply and demand conditions. We then detailed the methodology used to construct our Digital Money Readiness Index. Comprising of four pillars and sixteen constituent indicators, it represents the level of readiness of a country for digital money adoption. We then presented the ranking of the countries, noting that there are four different stages of digital money maturity. We analyzed our index against existing measures of cashlessness, showing that in general increasing levels of digital money readiness correlate to increased levels of cashlessness.

We contribute in a variety of ways. First, we have begun to widen the discussion of digital money to a broader academic audience. To date, the most detailed academic attention on money, and to a lesser extent digital, has come from anthropology (Maurer, 2006; Parry & Bloch, 1989) and history (Eagleton & Williams, 2011; Ferguson, 2012). Other academic attention has either focused on regulatory (Freedman, 2000; Rogers, 2006) or technical (Eslami & Talebi, 2011; Juang, 2007) aspects, or on the social benefits of particular digital money technologies (Jack & Suri, 2011; Morawczynski, 2014). This plethora of differing perspectives, although informative and insightful, does not currently constitute a coherent theoretical basis for research into digital money. Given the radical changes happening to the technologies of value exchange as information and communication technologies continue to diffuse in across the global economy, and the potential for major economic

and social benefits (Dodgson et al., 2012; Morawczynski, 2014), commencing a rigorous and wide ranging program of research into the phenomenon and its benefits is an urgent priority.

We also contribute through the provision of a comprehensive definition of digital money. This definition – currency exchange by electronic means – encompasses both the wide variety of existing digital means of exchange, as well as those future technologies that are undoubtedly to come. Our broader definition should enable a more systematic and coherent approach to understanding value exchange by electronic means. Our socio-technical systemic model of digital money, based upon Porter's (1990) diamond model, comprising of the institutional environment, enabling infrastructure, and supply and demand conditions, should provide the basis for further theoretical and empirical work. For instance, as digital money is a complex socio-technical system, this definition should enable the application of insights from technological innovation, which has investigated how the characteristics of successful technologies are rarely determined on technological grounds alone but instead are socially and institutionally constructed (Kaplan & Tripsas, 2008; Murmann & Frenken, 2006; Tushman & Murmann, 1998).

Our index has implications for policy makers. As we have begun to prescribe within this paper, there are actions that policy makers can undertake to assist a country in transitioning from one readiness stage to another. However we are barely scratching the surface of the policy insights that should be possible from analyses using the index, and the resultant interventions. For instance, as we intend to update the index annually, this first ranking and clustering of countries will act as a benchmark that can be used to both analyze and compare the progress of countries in their digital money readiness. Over time, we expect that the ranking in itself, as it is carried out year on year, to change only slightly. This implies that our readiness stages will remain constant until countries have made so much progress toward digital money readiness that the incipient category becomes meaningless. However we believe that this future state is not in the immediate future, and there is much insight that will be obtained from our index.

An important future direction of research is to investigate whether the claimed economic and social benefits of digital money are indeed present. This index begins to provide a measure of the

systemic readiness of a country to adopt digital money, and hence benefit from it. Furthermore our empirical linking of cashlessness and digital money readiness also provides a theoretical basis for considering the levels of cashlessness in a society as a proxy for digital money adoption. However, despite what commentators have argued, unlike other aspects of the post-industrial economy, the link between digital money readiness, subsequent adoption, and socio-economic benefits is not clear-cut. While increasing digitization in an economy can be clearly theoretically and intuitively linked to gross domestic product (GDP) growth, unemployment and consumer wellbeing (see for instance Katz & Koutroumpis, 2013), causal links between digital money and such coarse grained measures of socio-economic progress are not as intuitive. Instead, future research may need to focus on such socio-economic issues as the informal economy, financial inclusion, and criminality. Furthermore, given that one of the claims is that digital money increases the ‘flow of money’ (Dodgson et al., 2012), tracking changes in monetary velocity over time with either digital money readiness or cashlessness may provide evidence of such an increase.

To conclude, given the claimed socio-economic benefits of digital money, we have developed a Digital Money Readiness Index, which measures how systemically ready countries are for the adoption of digital money. We then reviewed the four stages of digital money maturity. We also analysed digital money readiness in relation to levels of cashlessness, demonstrating that there is a strong positive correlation between the two measures, but that some countries are performing better than their readiness score would indicate, while others not as well. We hope that this paper inspires researchers to further investigate the phenomenon of digital money.

## REFERENCES

- Arthur, W. B. 1994. *Increasing returns and path dependence in the economy*. Ann Arbor, MI: The University of Michigan Press.
- Autio, E., & Thomas, L. D. W. 2014. Innovation ecosystems: Implications for innovation management. In M. Dodgson, D. M. Gann, & N. Phillips (Eds.), *Oxford Handbook Of Innovation Management*: 204-228. Oxford, UK: Oxford University Press.
- Bohannon, P. 1959. The impact of money on an African subsistence economy. *Journal of Economic History*, 19(4): 491-503.
- Caillaud, B., & Jullien, B. 2003. Chicken & egg: Competition among intermediation service providers. *RAND Journal of Economics*, 34(2): 309-328.
- Cohen, B. J. 2000. Life at the top: International currencies in the 21st century. *Cuadernos de Economia*, 37(110): 9-34.
- Courtneidge, R. 2012. The implications of the Payment Services Directive and the Second E-Money Directive. *Journal of Payments Strategy & Systems*, 6(3): 219-224.
- Dave, S., & Baxter, G. 2013. Citi Cashless Intensity Ranking.
- David, P. A. 1985. Clio and the Economics of QWERTY. *The American Economic Review*, 75(2): 332-337.
- Dodgson, M., Gann, D. M., & Salter, A. J. 2008. *The Management of Technological Innovation*. Oxford, UK: Oxford University Press.
- Dodgson, M., Gann, D. M., Wladawsky-Berger, I., & George, G. 2012. From the digital divide to inclusive innovation: The case of digital money. London, UK: Royal Society for the encouragement of Arts, Manufactures and Commerce.
- Dosi, G. 1982. Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Research Policy*, 11(3): 147-162.
- Eagleton, C., & Williams, J. 2011. *Money: A History*. London, UK: The British Museum Press.
- Emery, F. E., & Trist, E. L. 1960. Socio-technical systems. In C. W. Churchman, & M. Verhulst (Eds.), *Management Sciences Models and Techniques*, Vol. 2. New York, NY: Pergamon.
- Erling, G. 2013. Cash is dead, long live cash. *Journal of Payments Strategy & Systems*, 7(1): 43-49.
- Eslami, Z., & Talebi, M. 2011. A new untraceable off-line electronic cash system. *Electronic Commerce Research & Applications*, 10(1): 59-66.
- Evans, D. S., Hagi, A., & Schmalensee, R. 2006. *Invisible Engines: How Software Platforms Drive Innovation and Transform Industries*. Cambridge, MA: The MIT Press.
- Evans, D. S., Webster, K., Colgan, G. S., & Murray, S. 2013. Payments innovation and the use of cash: 1-16: Market Platform Dynamics.
- Ferguson, N. 2012. *The Ascent Of Money: A Financial History Of The World*. New York, NY: Penguin Group.
- Freedman, C. 2000. Monetary Policy Implementation: Past, Present and Future – Will Electronic Money Lead to the Eventual Demise of Central Banking? *International Finance*, 3(2): 211.
- Geels, F. W. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6-7): 897-920.
- Geels, F. W., & Kemp, R. 2007. Dynamics of socio-technical systems: Typology of change processes and contrasting case studies. *Technology In Society*, 29(4): 441-455.
- Halpin, R., & Moore, R. 2009. Developments in electronic money regulation – the Electronic Money Directive: A better deal for e-money issuers? *Computer Law & Security Review*, 25(6): 563-568.
- Husson, F., Lê, S., & Pagès, J. 2011. *Exploratory Multivariate Analysis by Example Using R*. Boca Raton, FL: Chapman & Hall/CRC Press.
- Jack, W., & Suri, T. 2011. Mobile money: The economics of M-PESA, *NBER Working Paper*: 1-31. Cambridge, MA: National Bureau of Economic Research.
- Juang, W. S. 2007. D-cash: A flexible pre-paid e-cash scheme for date-attachment. *Electronic Commerce Research and Applications*, 6(1): 74-80.

- Kaplan, S., & Tripsas, M. 2008. Thinking about technology: Applying a cognitive lens to technical change. *Research Policy*, 37(5): 790-805.
- Katz, M. L., & Shapiro, C. 1994. Systems competition and network effects. *Journal of Economic Perspectives*, 8(2): 93-115.
- Katz, R. L., & Koutroumpis, P. 2013. Measuring socio-economic digitization: A paradigm shift, *Working Paper*: 1-31.
- Kaufman, L., & Rousseeuw, P. J. 1990. *Finding Groups In Data: An Introduction To Cluster Analysis*. Hoboken, NJ: John Wiley & Sons.
- Kelly, E. W. 1997. The future of electronic money: A regulator's perspective. *IEEE Spectrum*, 34(2): 21.
- Kemp, R. 2013. Mobile payments: Current and emerging regulatory and contracting issues. *Computer Law & Security Review*, 29(2): 175-179.
- Kent, J. 2012. Dominant mobile payment approaches and leading mobile payment solution providers: A review. *Journal of Payments Strategy & Systems*, 6(4): 315-324.
- Kim, B. 2003. Managing the transition of technology life cycle. *Technovation*, 23(5): 371-381.
- Lee, B.-C., & Longe-Akindemowo, O. 1999. Regulatory Issues in Electronic Money: A Legal-Economics Analysis. *Netnomics*, 1(1): 53-70.
- Mann, R. J. 2006. *Charging Ahead: The Growth and Regulation of Payment Card Markets Around the World* Cambridge, UK: Cambridge University Press.
- Maurer, B. 2006. The anthropology of money. *Annual Review of Anthropology*, 35: 15-36.
- Mbiti, I., & Weil, D. N. 2013. The Home Economics of E-Money: Velocity, Cash Management, and Discount Rates of M-Pesa Users. *American Economic Review*, 103(3): 369-374.
- Miliani, L., Purwanegara, M. S., & Indriani, M. T. D. 2013. Adoption Behavior of E-Money Usage. *Information Management & Business Review*, 5(7): 369-378.
- Misra, S. K., Javalgi, R. G., & Scherer, R. F. 2004. Global electronic money and related issues. *Review of Business*, 25(2): 15-24.
- Morawczynski, O. 2014. Exploring the usage and impact of "transformational" mobile financial services: The case of M-PESA in Kenya. *Journal of Eastern African Studies*, 3(3): 509-525.
- Murmann, J. P., & Frenken, K. 2006. Toward a systematic framework for research on dominant designs, technological innovations, and industrial change. *Research Policy*, 35(7): 925-952.
- OECD. 2007. Handbook on Constructing Composite Indicators, *Methodology and user guide*. Paris, France: OECD Publications.
- Panurach, P. 1996. Money in Electronic Commerce: Digital Cash, Electronic Fund Transfer, and Ecash. *Communications of the ACM*, 39(6): 45-50.
- Parry, J., & Bloch, M. 1989. *Money And The Morality Of Exchange*. Cambridge, UK: Cambridge University Press.
- Peha, J. M., & Khamitov, I. M. 2004. PayCash: a secure efficient internet payment system. *Electronic Commerce Research & Applications*, 3(4): 381-388.
- Porter, M. E. 1990. *The Competitive Advantage of Nations*: Jossey Bass.
- Roberds, W. 1998. The impact of fraud on new methods of retail payment. *Economic Review*, 83(1): 42.
- Rochet, J. C., & Tirole, J. 2002. Cooperation among competitors: Some economics of payment card associations. *RAND Journal of Economics*, 33(4): 549-570.
- Rochet, J. C., & Tirole, J. 2006. Two-sided markets: A progress report. *RAND Journal of Economics*, 37(3): 645-667.
- Rogers, C. 2006. Doing without money: a critical assessment of Woodford's analysis. *Cambridge Journal of Economics*, 30(2): 293-306.
- Rogers, E. M. 2003. *Diffusion of Innovations* (5th ed.). New York: Simon & Schuster.
- Simmel, G. 1990. *The Philosophy of Money*. London, UK: Routledge.
- Singh, S. 1996. The cultural distinctiveness of money. *Sociological Bulletin*, 45(1): 55-85.
- Singh, S. 1999. Electronic money: Understanding its use to increase the effectiveness of policy. *Telecommunications Policy*, 23(10/11): 753.
- Smith, A. 1994. *The Wealth of Nations*: Modern Library.
- Snellman, J. S., Vesala, J. M., & Humphrey, D. B. 2001. Substitution of Noncash Payment Instruments for Cash in Europe. *Journal of Financial Services Research*, 19(2-3): 131-145.

- Szerb, L., Acs, Z. J., Autio, E., Ortega-Argiles, R., & Komlosi, E. 2013. REDI: The Regional Entrepreneurship and Development Index - Measuring Regional entrepreneurship: 1-171: University of Groningen; Imperial College London; University of Pecs; Utrecht University.
- Thomas, H., Jain, A., & Angus, M. 2013. The global journey from cash to cashless, *MasterCard Advisors' Cashless Journey*: 1-15: MasterCard Advisors.
- Trochim, W. M. K., & Donnelly, J. P. 2008. *The Research Methods Knowledge Base*. Mason, OH: Cengage Learning.
- Tu, T. T., Hsin, H.-C., & Chiu, Y. H. 2011. Investigation of the factors influencing the acceptance of electronic cash stored-value cards. *African Journal of Business Management*, 5(1): 108-120.
- Tushman, M. L., & Murmann, J. P. 1998. Dominant designs, technology cycles, and organizational outcomes. *Research in Organizational Behavior*, 20: 231-266.
- Westland, J. C. 2002. Preference Ordering Cash, Near Cash, and Electronic Cash. *Journal of Organizational Computing & Electronic Commerce*, 12(3): 223-242.
- Williamson, O. E. 1975. *Markets And Hierarchies: Analysis And Antitrust Implications: A Study In The Economics Of Internal Organization*. New York, NY: Free Press.
- Wolman, D. 2013. The End Of Money. Philadelphia, PA: Da Capo Press.
- Woodford, M. 2000. Monetary Policy in a World Without Money. *International Finance*, 3(2): 229.

**TABLE 1 – Indicators**

<b>Indicator</b>	<b>Source</b>	<b>Detail</b>
Business Sophistication	Pillar 11 (Business Sophistication), Global Competitiveness Report, 2013; released by World Economic Forum	Measures the quality of the business networks and the quality of individuals firms' operations and strategies
E-government	Index of online services delivery, E-Government Development Index, 2013; released by the United Nations	Measures the proportion of services delivered online in a country
Electronic Payments	Global Financial Inclusion Database, 2013; released by the World Bank	Measures the proportion of population that have made an electronic payment
Financial Market Development	Pillar 8 (Financial Market Development), Global Competitiveness Report, 2013; released by World Economic Forum	Measures the availability and affordability of financial services, as well as function of equity market, soundness of banks. access to loans and venture capital
Financial restrictions index	Banking licenses refused, from World Bank surveys on Bank Regulation, 2011; released by the World Bank. Where 2011 data not present, most recent of 1999, 2003 and 2007 was used.	Measures the overall restrictions on banking activities in a country
ICT readiness	ICT Readiness Sub-Index, Global Information Technology Report 2013; released by World Economic Forum	Measures the degree to which a society has an affordable ICT infrastructure and the skills to use it
ICT usage	ICT Usage Sub-Index, Global Information Technology Report 2013; released by World Economic Forum	Measures individual, business, and government usage of ICTs in their day-to-day activities
Innovation Environment	Pillar 12 (Innovation), Global Competitiveness Report, 2013; released by World Economic Forum	Measures the capacity for innovation in a country, including quality of scientific research, company spending on R&D, patents, and government procurement of advanced technology
Market efficiency	Pillar 6 (Goods market efficiency), Global Competitiveness Report, 2013; released by World Economic Forum	Measures levels of market competition, both domestic and foreign, which influences business productivity, by ensuring that the most efficient firms, producing goods demanded by the market, are those thrive.
Metros	List of metro systems, Wikipedia, 2013	Measures the number of low payment metro systems in a country
Perceived corruption	Corruption Score, Corruption Perception Index, 2012; released by Transparency International	Measures the perceived levels of public sector corruption in countries around the world
Online retail	Euromonitor 2012	Measures the proportion of retail transactions that are done online in a country
Regulatory quality	Worldwide Governance Indicators, 2013; released by World Bank.	Measures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development
Rule of law	Rule of Law Indicator, Worldwide Governance Indicators, 2012; released by World Bank	Measures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, and crime and violence.
Technology diffusion	Availability of latest technologies indicator, Global Information Technology Report 2013; released by World Economic Forum	Measures the rate at which the latest technologies become available in an economy, as a proxy for the likelihood of adoption of new technologies
Toll-ways	Global List of Toll Operations, International Bridge, Tunnel and Turnpike Association, 2013	Measures the number of toll-ways in a country

**TABLE 2 – Indicator Correlations**

	Mean	S.d	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Business sophistication	0.00	1.00															
2. E-government	0.00	1.00	0.81***														
3. Electronic payments	0.00	1.00	0.82***	0.81***													
4. Financial development	0.00	1.00	0.86***	0.78***	0.94***												
5. Financial restrictions index	0.00	1.00	0.70***	0.82***	0.70***	0.64***											
6. ICT readiness	0.00	1.00	-0.33**	-0.31**	-0.44***	-0.45***	-0.21										
7. ICT usage	0.00	1.00	0.76***	0.64***	0.76***	0.77***	0.51***	-0.36***									
8. Innovation Environment	0.00	1.00	0.77***	0.66***	0.75***	0.74***	0.54***	-0.31**	0.79***								
9. Market efficiency	0.00	1.00	0.82***	0.59***	0.80***	0.87***	0.46***	-0.49***	0.73***	0.72***							
10. Metros	0.00	1.00	0.49***	0.41***	0.51***	0.55***	0.28**	-0.25*	0.48***	0.48***	0.47***						
11. Perceived corruption	0.00	1.00	0.56***	0.30*	0.43**	0.52***	0.12	-0.21	0.57***	0.49***	0.60***	0.21					
12. Online retail	0.00	1.00	0.33**	0.23*	0.44***	0.48***	0.11	-0.33**	0.42***	0.33**	0.45***	0.37***	0.17				
13. Regulatory quality	0.00	1.00	0.94***	0.87***	0.82***	0.82***	0.76***	-0.35***	0.77***	0.76***	0.72***	0.46***	0.49***	0.34**			
14. Rule of law	0.00	1.00	0.93***	0.80***	0.87***	0.90***	0.65***	-0.43***	0.86***	0.89***	0.86***	0.55***	0.63***	0.41***	0.90***		
15. Technology diffusion	0.00	1.00	-0.86***	-0.78***	-0.93***	-0.97***	-0.67***	0.46***	-0.73***	-0.73***	-0.87***	-0.55***	-0.45**	-0.43***	-0.81***	-0.89***	
16. Toll-ways	0.00	1.00	0.86***	0.84***	0.84***	0.83***	0.75***	-0.37***	0.75***	0.74***	0.72***	0.50***	0.38**	0.42***	0.89***	0.87***	-0.82***

**TABLE 3 – Weightings Applied**

	<b>Rule of Law</b>	<b>Regulatory Quality</b>	<b>Market Efficiency</b>	<b>Innovation Environment</b>	
Pillar 1	0.9568	0.9528	0.9055	0.9329	
	<b>Bank Restrictions</b>	<b>Financial Market Development</b>	<b>ICT Readiness</b>		
Pillar 2	(-)0.6396	0.7668	0.8499		
	<b>Electronic Payments</b>	<b>E-Commerce</b>	<b>Metro Systems</b>	<b>Toll-ways</b>	<b>E-Government</b>
Pillar 3	0.8660	0.5352	0.7019	0.6060	0.8166
	<b>Bus Sophistication</b>	<b>Technology Diffusion</b>	<b>Corruption</b>	<b>ICT Usage</b>	
Pillar 4	0.9512	0.9528	(-)0.9289	0.9572	
	<b>Pillar 1</b>	<b>Pillar 2</b>	<b>Pillar 3</b>	<b>Pillar 4</b>	
Cross Pillar	0.9712	0.9291	0.9029	0.9840	

**TABLE 4 – Cluster Descriptions**

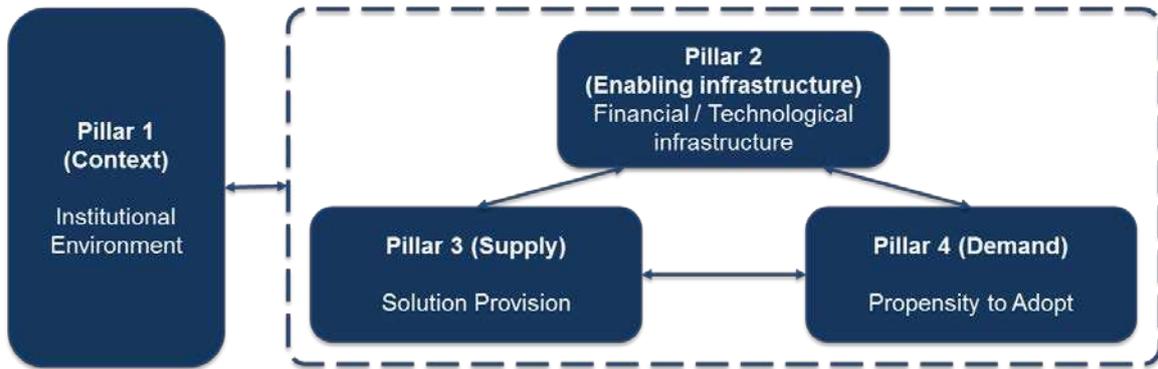
<b>Cluster 1 - Incipient</b>						
	<b>V Test</b>	<b>Mean in category</b>	<b>Overall mean</b>	<b>SD in category</b>	<b>Overall SD</b>	<b>P Value</b>
Pillar 3	-4.93	-0.43	0.03	0.17	0.54	0.00
Pillar 1	-6.04	-0.93	-0.00	0.37	0.87	0.00
Pillar 4	-6.17	-0.97	0.00	0.31	0.89	0.00
Pillar 2	-6.41	-0.64	0.01	0.23	0.57	0.00

<b>Cluster 2 - Emerging</b>						
	<b>V Test</b>	<b>Mean in category</b>	<b>Overall mean</b>	<b>SD in category</b>	<b>Overall SD</b>	<b>P Value</b>
Pillar 2	-0.99	-0.07	0.01	0.25	0.57	0.32
Pillar 1	-2.40	-0.27	-0.00	0.26	0.87	0.02
Pillar 4	-2.43	-0.28	0.00	0.23	0.89	0.02
Pillar 3	-3.04	-0.18	0.03	0.21	0.54	0.00

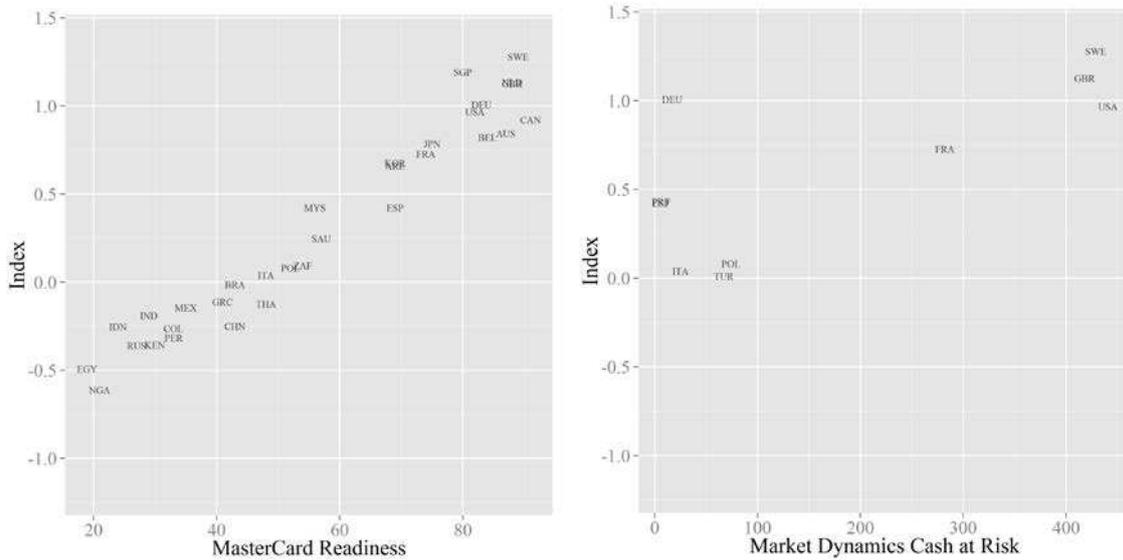
<b>Cluster 3 – In-Transition</b>						
	<b>V Test</b>	<b>Mean in category</b>	<b>Overall mean</b>	<b>SD in category</b>	<b>Overall SD</b>	<b>P Value</b>
Pillar 4	3.36	0.77	0.00	0.36	0.89	0.00
Pillar 1	2.95	0.66	-0.00	0.30	0.87	0.00
Pillar 3	2.87	0.43	0.03	0.30	0.54	0.00
Pillar 2	1.47	0.22	0.01	0.21	0.57	0.14

<b>Cluster 4 – Materially Ready</b>						
	<b>V Test</b>	<b>Mean in category</b>	<b>Overall mean</b>	<b>SD in category</b>	<b>Overall SD</b>	<b>P Value</b>
Pillar 1	7.18	1.38	-0.00	0.17	0.87	0.00
Pillar 2	7.15	0.91	0.01	0.24	0.57	0.00
Pillar 4	6.99	1.37	0.00	0.23	0.89	0.00
Pillar 3	6.80	0.84	0.03	0.40	0.54	0.00

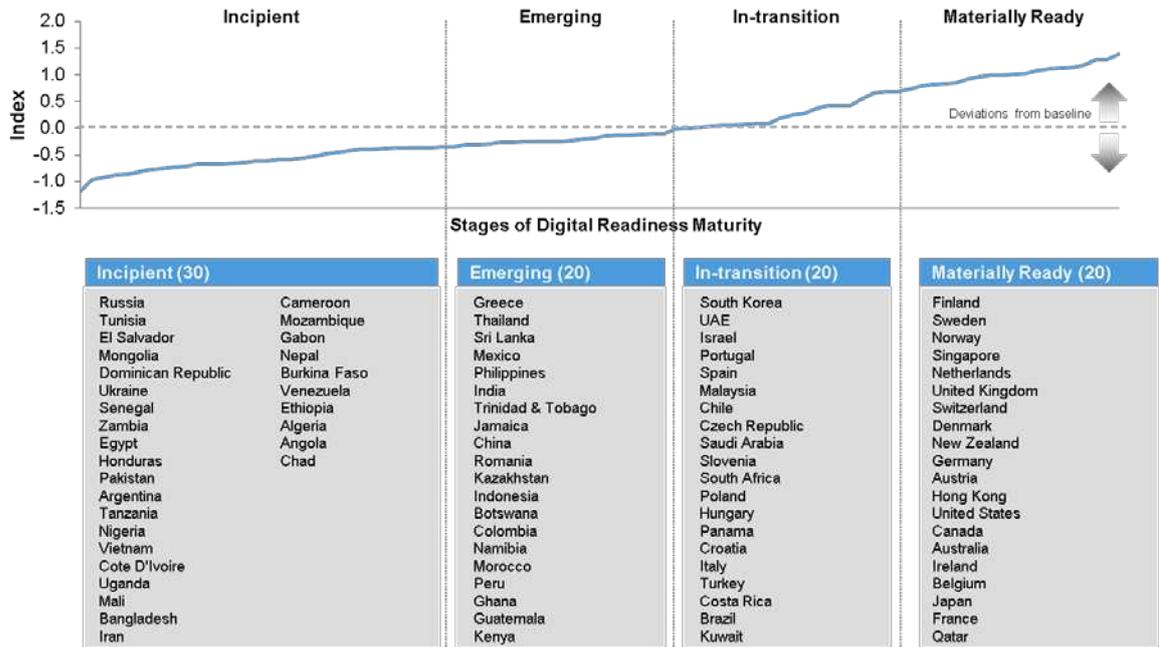
**FIGURE 1 – Digital Money Ecosystem**



**FIGURE 2 – Scatterplot of Index with MasterCard Cashlessness Readiness Index and Market Dynamics Cash-At-Risk Score**



**FIGURE 3 – Country Rankings by Stage**



**FIGURE 4 – Correlation of Digital Money Readiness Index with Cashless Intensity and MasterCard Cashlessness Index**

