Use of biometric technology in developing countries[*]

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1. Introduction

The success of governments in combating corruption or delivering public services efficiently relies on positive and accurate identification of their citizens and the ability to cross-reference databases and information across government departments and agencies. This is only possible if a national system that allows individuals to be uniquely identified exists. Unfortunately, this is not the case for many developing countries.

As a result, government programs work in isolation, each with its own database of beneficiaries often not digitized and that cannot be merged with others. These databases typically contain data entry mistakes as well as duplicate and dead entries causing substantial mis-targeting of beneficiaries and pilferage in the delivery of public services.

In these places, the implementation of a unique identification system could improve dramatically the efficiency of the government as well as the market: credit and insurance markets could expand as financial institutions would be more willing to provide services and the labor market would work better as employers could verify diplomas and certificates.

One way to establish the identity of individuals is through their biometrics. A biometric is a measure of identity based on a physiological (fingerprint, face, eye iris or retina) or behavioral (speech or signature) characteristic. It is an effective personal identifier because it is unique to and embodied in each person, so it cannot be forgotten, lost or stolen like other conventional identification methods.

Biometric identification requires a device such as a camera or a scanner to capture the image, recording, or measurements of an individual's characteristics and computer hardware and software to extract, encode, store, and compare these characteristics. Because the process is automated, biometric decision making is generally very fast, in most cases taking only a few seconds in real time (GAO, 2005).

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The recent advancements in recognition technology coupled with increases in digital storage capacity and computer processing speed have made biometric technology feasible in many identification applications.

Criminal identification is far and away the oldest, most widespread, large scale identification use of biometric systems to identify suspects. The technology is also used to gain access to facilities and to replace passwords to authenticate individuals accessing computers and networks. For example, more than half the nuclear power plants in the United States employ biometric hand geometry systems (GAO, 2005). Many federal agencies in the US, such as the Office of Legislative Counsel of the U.S. House of Representatives, Department of Defense (DOD), Department of Energy, and Department of Justice, are adopting biometrics recognition systems to protect confidential files and documents.

In addition, biometric technology has been used in developed countries to combat fraud. Leading banks and other financial institutions are piloting biometric recognition systems to authenticate ATM users and to combat credit and debit card fraud. Hand geometry and iris and facial recognition have been deployed at ATMs in North America, Europe, and Asia. Even firms that offer Internet shopping are considering biometric technologies to authorize various types of transactions.

Biometrics can also be used in monitoring and surveillance applications. For example, biometrics can be added to time and attendance processes to prevent hourly employees from punching time cards for their absent friends, which costs employers hundreds of millions of dollars annually. It is also being used by major casinos in North America to spot known cheaters.

Finally, biometric technologies are being used in countries as diverse as India, South Africa, Philippines and Spain as the basis for the national identification system, eliminating the need for multiple identification mechanisms. Biometrics can help determine whether applicants are already enrolled under a different identity and thus can prevent individuals from cheating public sector benefits programs by collecting benefits under multiple identities. Related, with more accurate data on beneficiaries and allocation of benefits, government officials may have less room for diverting public resources (Reinikka and Svensson, 2004; Olken, 2006; Bertrand et al., 2007; Niehaus and Sukhtankar, 2009; Atanassova et al. 2009). In India, the implementation of the biometrics-based Multipurpose National Identity Card will replace all other forms of identification and enable citizens to access public services and subsidies on food, energy and education that now suffer from major pilferage (Planning Commission, 2005; The Hindu, 2009; WSJ, 2009).

In this paper we focus on the potential of biometric technology in improving the credit market in Malawi, a country without a unique identification system. In these places, identity fraud –the use of someone else's identity or a fictitious one– to gain access to services unavailable to the individual is rather common. Lenders tell anecdotes of past borrowers purposefully defaulting

and trying to obtain a fresh loan from the same or another institution, and although less common in developing countries because markets are less developed, one could imagine sick individuals without coverage using the insurance policy of their healthier friends or relatives. The response of lenders and insurance companies has been to restrict the supply of such services.

Indeed, Africa and Malawi in particular have one of the lowest levels of credit penetration in the world.

In the case of credit, biometric technology can make the threat of future credit denial credible because it makes it easier for financial institutions to withhold new loans from past defaulters, and to reward responsible past borrowers with increased credit. As a result, individuals may take out smaller loans or avoid borrowing altogether; borrowers may have greater incentives to ensure that production is successful, either by exerting more effort or choosing less risky projects, and –whenever production could cover the loan repayment– may be less likely to default intentionally or opportunistically.

The rest of the paper is organized as follows. Section 2 describes the results of pilot program and discusses the potential for biometrics to serve as the basis of identification of a national credit bureau, Section 3 describes the benefits of information sharing across lenders and Section 4 deals with the challenges of implementing such a large-scale national identification system. Section 5 concludes.

2. Use of biometric technology in rural credit markets of Malawi

Giné, Goldberg and Yang (2009) implemented a field experiment with smallholder paprika farmers that applied in 2007 for an agricultural input loan from a government lender, MRFC. Farmers in the study were randomly allocated to either a control group or a treatment group where each member had a fingerprint collected as part of the loan application. Both treatment and control groups were given a training session on the importance of credit history in ensuring future access to credit.

The authors chose fingerprint recognition over face, iris or retina recognition because it is one of the cheapest, best known and most widely used technologies. Fingerprinting technology extracts features from impressions made by the distinct ridges on the fingertips and has been commercially available since the early 1970s. There are more than 75 companies ensuring a very competitive market. An image of the fingerprint was captured by a portable optical scanner attached to a laptop, and was then enhanced, and converted into a template. Optical technology is the oldest and most widely used; it requires that the finger be placed on a coated platen, typically made of hard plastic. In most devices, a charged coupled device converts the image, with dark ridges and light valleys, into a digital signal. The brightness is adjusted automatically or manually to produce a usable image.

During enhancement, “noise” caused by such things as dirt, cuts, scars, and creases or dry, wet, or worn fingerprints is reduced, and the definition of the ridges is enhanced. To minimize noise, farmers were instructed to wash their thumbprints before placing it on the scanner, and the scanner was also cleaned after each impression.

The industry uses three main metrics to determine the accuracy of a given technology: failure to enroll rate (FTER), false match rate (FMR), and false nonmatch rate (FNMR). FTER measures the probability that a person will be unable to enroll primarily due to insufficiently distinctive biometric data. During the collection process in Malawi, only about 2 per cent of the sample of the 1,600 fingerprinted farmers had the left thumbprint recorded, rather than the required right thumbprint because the scanner failed to capture it. As it turns out, many farmers grow tobacco which requires the heavy use of fingers in the transplanting of seedling. Over the years, the fingerprint ridges become too worn to be captured.

A false match occurs when a system incorrectly matches an identity, and FMR is the probability of individuals being wrongly matched. They may occur because there is a high degree of similarity between two individuals’ characteristics. False non-matches occur because there is not a sufficiently strong similarity between an individual’s enrollment and the recorded fingerprint.

The software in Malawi uses an algorithm based on the extraction of minutiae points relating to breaks in the ridges of the fingertips. During demonstration sessions everyone selected was correctly identified, so both the FMR and the FNMR rate were zero, albeit with a small sample.

The study shows that for the subgroup of farmers with the highest ex ante default risk, fingerprinting led to increases in the repayment rates of about 40 percent. By contrast, fingerprinting had no impact on repayment for farmers with low ex ante default risk. This higher repayment rates are due to fingerprinted borrowers requesting smaller loan sizes and devoting more land and other inputs to paprika.

A rough cost-benefit analysis of the pilot experiment suggests that the benefits from improved repayment greatly outweigh the costs of equipment and fingerprint collection.

The results suggest that biometric technology can improve repayment, but if these data are not shared with other lenders (or even other institutions such as utilities, durable goods stores, etc), one cannot prevent defaulters from accessing a loan or services from these another institutions. A credit bureau which allows the sharing of credit information across institutions can help enhance the culture of repayment and facilitating access to finance nationwide. The key input into a credit bureau is accurate identification data, so biometrics can serve as the basis for such identification system such as the one in Uganda and Nigeria (Mylenko, 2007).

The following section describes the benefits of credit reporting as well as some of the arguments against it.

3. Credit Reporting

Credit information systems refer to databases of information on borrowers in a financial system. Information in these systems is available on individual consumers and/or firms and can be drawn from creditors as well as available public information sources.[1]

As mentioned, financial markets are characterized by the problem of asymmetric information between borrowers and creditors. Creditors have less information on borrowers and their ability and willingness to make good on debt obligations than borrowers do themselves. Credit information sharing systems can reduce the extent of asymmetric information by making a borrower's complete credit history available to existing and potential lenders.

Historically the concept of credit information sharing was pervasive between trade creditors and merchants, who exchanged negative lists of information on common debtors amongst their respective communities to reduce the risk of delinquencies and non-payments. Lenders armed with this data avoided lending to high risk individuals with poor repayment histories, defaults or bankruptcies. In the more advanced economies, credit scoring and advanced quantitative models appeared on the banking scene in the mid 1900s and simplified the underwriting process by taking away the subjective judgment aspect that traditionally defined lending processes. The resulting automation of screening new applicants and credit granting processes enabled the lending community to widely expand their portfolios at reduced costs.

While the objective of a credit information sharing system is to compile information from creditors and accessible public information sources on borrower credit histories, credit information sharing systems have developed in different parts of the world at different times and often for different reasons. In some countries credit information databases reside within Central Banks and are primarily used for systemic risk monitoring of large exposures. In others, such as in the US, where credit bureaus first emerged in the early 1900s, credit reporting has thrived in the private sector and involves the compilation of information on small-ticket consumer and small business loans.

Benefits of credit information sharing

Over the years, much has been written about the benefits of credit information sharing. These can be broadly summarized in the following categories:

Advantages to lenders

(i) Lenders can make more informed credit granting decisions with information on borrower credit histories. This lowers the risk associated with incorrect credit risk assessments and

[1] Miller at al., p.27

inappropriate approvals. Consequently, lenders can lower the level of non-performing loans in their portfolio and maintain higher quality loan portfolios.[2]

(ii) Lenders stand to benefit from operational efficiencies introduced by automated screening and lending processes.[3] Luoto et. al. (2007) find that the introduction of a major Guatemalan microfinance lender's branches into a credit reporting system improved the number of applications processed per loan officer per month, by 55%, implying huge operational efficiency gains to the lender. Of banks surveyed in 34 countries in 2001-02 by the World Bank, approximately 50 % indicated that they had witnessed a decline in operating costs by more than 25% as a result of the use of credit registries.

(iii) McIntosh and Wydick (2005) show that credit bureaus can help micro-lenders identify pockets of over-indebtedness amongst their clients, as they are aware of all other outstanding debt obligations of their clients, and consequently place limits on new credit.[4] McIntosh et. al (2006) shows that credit information sharing can encourage consumers to meet their obligations, when they know that non-compliance with obligations will be entered into a database and accessed by creditors, and potentially service suppliers.

(iv)The availability of credit information sharing systems may lead creditors to shift from collateral-based lending policies to more information-based lending policies, which can impact the cost of credit and service. Collateral-based lending, which is still very prevalent all over the world, is problematic in case of borrowers without sufficient collateral, who risk being denied access to formal financial services. Collateral is also problematic for lenders, as the costs of collecting on collateral and the time and effort involved can be significant. Another issue with collateral-based lending is that the most acceptable forms of collateral continue to remain land and buildings, and therefore there is a mismatch in what can be used as collateral, and the types of collateral firms typically hold. Safavian et. al. (2006) look at enterprise survey data on 60 low and middle income countries, and find that while 22% of assets held by private firms are comprised of land and building, the majority of firms' assets are of movable nature, including machinery and receivables, which are not typically accepted as usable forms of collateral for bank loans.

Lending decisions that are facilitated by the use of credit information data can have significant cost savings for lenders. The resultant cost savings enables lenders to diversify their product offerings, and develop products that are more targeted and suited towards meeting needs of their borrower clients.[5]

Advantages to the market and growth in private credit

[2] Pagano and Jappelli (1993), Padilla and Pagano, (1997, 2000). Djankov et. al. (2007), and McIntosh and Wydick (2007).
[3] Ibid.
[4] McIntosh and Wydick, 2005.
[5] Jappelli and Pagano, 2002.

Empirical research shows that credit information sharing is critical for small businesses to lower financing constraints. According to a study by Love and Mylenko (2004), based on information from 5000 firms in 51 countries, the percent of firms reporting financing constraints declined from 49% in countries without credit information sharing systems, to 27% in those countries that did have such systems. The same study showed that the probability of a small firm obtaining a bank loan increased from 28% in countries without credit bureaus to 40% in those that did have credit bureaus.

Djankov et al. (2007) find that better creditor rights and the presence of credit registries are associated with a higher ratio of private credit to GDP. Additionally private credit to GDP ratios rise following improvements in creditor rights or the introduction of credit registries.[6] Love and Mylenko (2004) and Jappelli and Pagano (2006) also find that higher lending is associated with the presence of credit registries (specifically private credit registries). Turner and Varghese (2007) show, while looking at the use of credit information sharing in Latin America and the Caribbean, that there are statistically significant increases in private sector lending (as a share of GDP), associated with increased rates of coverage by private bureaus. As one moves to full-file coverage, private sector lending can rise by 60 percentage points of GDP, all else being equal (Turner and Varghese 2007, 19).

Advantages to the borrower

Miller et al. (2003) find that another benefit of instituting a credit reporting system is that it acts as a borrower disciplining device. Credit information sharing systems enable the creation of "reputational collateral." Borrowers understand that delinquencies or late payments detract from the value of such reputational collateral and have a greater incentive to meet their debtor obligations. [7]

It is also in the interest of non-defaulting consumers to have their histories available so that creditors with whom they have relationships know that they are creditworthy. Borrowers whose information is reported on a credit reporting system can thus obtain lower rates and better conditions for various financial products.

Evidence against information sharing

The benefits of credit information sharing notwithstanding, researchers have also questioned the legitimacy of information sharing. Gehrig and Stenbacka (2001), find that information sharing in the financial services industry leads to relaxation of competitive practices as relationship lending becomes less important. In other words information sharing weakens competition for the formation of banking relationships – serves as an institutional mechanism for redistribution of surplus from talented entrepreneurs to banks and that the implied anti-competitive effects reduce

[6] Djankov et al. (2007), p.5
[7] Miller et al., pp. 26-27

the social returns of information sharing. It also leads to exclusion of creditworthy borrowers from the credit market. Authors argue that information sharing increases prices for borrowers without credit histories and undermine the importance of banking relationships.

Jappelli and Pagano (1999, 18-19) find that lenders are generally averse to information sharing due to fear of competition and poaching of clients. They lose monopoly power developed with exclusive access to customer information. Unless there are specific provisions to protect lenders, as in the case of the United States, where traditionally rules limited branching across states, lenders would be hesitant to share information. So in the US, credit bureaus existed in the early 1920s. In Europe on the other hand banks were traditionally allowed to compete nationally, thus causing credit bureaus to develop later and on a smaller scale. If there is a dominant bank (as in the case of Italy), there can be hesitance to join a bureau. The Italian credit bureau, CRIF for instance, was established in 1990 by small and medium-sized banks in the Northeastern part of Italy. These banks had little to fear from others due to highly localized nature of markets. However, the fact that the big nationwide banks began to join the bureau over the years show that the estimated benefits of joining it, outweighed the costs (Jappelli and Pagano 1999, 18-19).

Other factors determining the extent (or limit of) sharing of information between creditors are determined by borrower mobility (which is a big factor in the case of the European Union, and the whole global economy at large) and population heterogeneity (Pagano and Jappelli 1993).

Some of the other drawbacks that have been identified are: information sharing does not address some causes of over-indebtedness (unexpected life events, etc.), borrowers may not be happy with personal data being shared – privacy concerns, higher risk of identity thefts, consumer associations are not convinced that credit data accurately reflects individual situations, consumers may be excluded from services, in case of information sharing between financial institutions and service providers (Expert Group on Credit Histories 2009, 16).

Challenges notwithstanding, credit reporting systems are still recognized as effective tools towards mitigating adverse selection and moral hazard problems in credit decision making processes. The rapid growth in the number of credit reporting systems worldwide, both privately operated and Central Bank operated, is a testament to this. The use of automated credit information tools and credit scoring applications enables creditors to acquire information quickly and at a lower cost. In the old days of relationship lending, banks relied on the personal knowledge and relationships built with customers by loan officers, to assess and process loans. In fact this form of loan assessment and approval still exists in several parts of the world, where credit bureaus do not exist or do not function as required.

As the world moves on to complex financial markets where lenders are driven by competition to improve operating margins and increase profitability, tools that enhance automated screening procedures and the ability of lenders to make quicker lending decisions become invaluable. Credit information sharing systems form one set of such tools that can enhance the effectiveness

of the lending sector. Over the past few years, the world has definitely seen an upward trend in the development of credit reporting systems worldwide, and their importance cannot be undermined.

Negative and Positive Credit Reporting

Negative information sharing includes simple statements of past defaults or arrears and is also known as black or negative data. Positive information sharing includes detailed reports on applicant's assets and liabilities, guarantees, debt maturity structure, pattern of repayments, employment, family history, account balances, number of inquiries, debt ratios, on-time payments, credit limits, account type, loan type, lending institution, interest rates and public record data, etc, and is also known as white or positive data. Several OECD countries including the U.S., the UK and most other European countries permit positive reporting. The U.S., perhaps, represents the most open credit information sharing environment as per the Fair Credit Reporting Act which placed the extension of credit as a primary objective for lenders.

Empirical research (Barron and Staten 2003, Jappelli and Pagano 2000, Turner and Varghese 2007, Love and Mylenko 2003) indicates that positive information sharing, also known as full-file information sharing can lead to a significant reduction in bad debt rates, a reduction in the likelihood that credit is extended to bad borrowers, and an increase in the number of better quality customers becoming eligible for credit. Turner et al. (2009) explain how negative-only reporting fails to accurately depict any one individual's entire credit history, because the reporting of negative data is contingent on the occurrence of a negative event, such as a delinquency, or a late payment. For the majority of borrowers, however, such events are rare. A data furnisher that provides negative-only information fails to include information about accounts that have never entered these conditions. Therefore, a credit file that is derived from negative-only information excludes all positive repayment behavior, as well as evidence of the existence of accounts that are current. In a negative-only system, consumers who have no credit history are equivalent to consumers who have established credit accounts and have met their obligations to repay without an occurrence of delinquency, default, collection, or bankruptcy. This partial survey of a person's credit history provides a less robust prediction of credit risk and is a very poor indicator of credit capacity.

The major benefit of increased level of information sharing is the ability to more accurately assess credit risk and capacity, and thereby fewer incorrect credit granting decisions and lesser instances of borrower defaults. Turner and Varghese (2007) have also shown that full-file reporting allows for the extension of credit to traditionally discriminated borrower groups, including women, racial minorities, low-income borrowers, and younger segments of the population.

In addition to positive and negative credit reporting, information-sharing can be comprehensive across financial sectors such as banking, retail, credit cards, insurance, or can be limited to

certain sectors as defined by data sharing regulations or by market outcomes. Comprehensive reporting across financial sectors has been empirically shown to increase access to credit, provide fairer access to credit, and decrease risk through fewer lender mistakes and fewer borrower defaults. The more inclusive and comprehensive the information a lender has on a borrower's complete financial and payment history, the better lending decisions can be made (Turner et al. 2009, Barron and Staten 2003, Love and Mylenko 2004).

Traditionally private bureaus did not capture information on micro and small business segments of the economy, and this naturally fell beyond the purview of Central Bank operated registries. Increasingly, however, as the benefits of comprehensive credit reporting are becoming known, credit information sharing systems have started collecting data from microfinance institutions and small and medium businesses to bolster their databases. Several developing market credit bureaus such as in India, Turkey and Saudi Arabia have been incorporating small business credit reporting in their business plans to avoid these mistakes (IFC 2006, 2).

In addition to developing comprehensive credit information sharing systems, operators are looking at "non-traditional" or "alternative" sources of information to bolster information on clients with limited credit histories. An alternative lies in data collected from the services sector, such as utility payments and telecom bills, all of which are much more prevalent than financial accounts. PERC studies have shown that segments of the U.S. population that are least likely to be in the mainstream credit market, such as ethnic minorities, lower income households, the young and the elderly benefitted most positively from the addition of non-financial information to their credit files (Turner et al. 2006, 2008).

4. Challenges in the implementation of biometric systems

Despite the encouraging results from the pilot in Malawi and the success of biometric technology in controlled laboratory environments, there are still a few concerns and challenges when collecting and using biometrics in actual environments with plans to a major scaling up to establish an identification system at a national level.

- *Not everyone can be enrolled in a fingerprint-based identification system.* Fingerprints can be unrecognizable due to cuts or burns or extreme weight gain or loss. In addition, older individuals may have poor fingerprints, or the operation of fingerprint readers may be jeopardized due to arthritis. In some areas recovering from years of conflict, individuals may lack fingers altogether. In other cases skin pigmentation obfuscates the possibility of getting readable prints. In the most comprehensive study to test the process and customer attitude during the recording of biometric information, the UK Passport Service Trial reports an enrolment success rate of 100 per cent for the 9,250 non-disabled participants and 96 per cent for the 750 disabled participants. Interestingly, the enrolment rate is much lower among the

black population. As already mentioned, in the Malawi pilot only 2 per cent of the sample had another fingerprint recorded than the required one.

- *The accuracy of biometric technology remains to a large extent untested.* Biometric companies report very high accuracy rates from highly controlled trials which typically use artificially generated data. However, because the performance of a technology depends greatly on the context, trials using real life data are far less impressive. For example, the UK Passport Service Trial reports that only 80 per cent of the cases could be correctly verified, younger individuals being more successful than older. According to a recent review of available systems, only a handful of products achieved an equal error rate of under 3%, and the performance of most was much worse.[8] Some experts have also cautioned about the use of fingerprinting as evidence in the judiciary process. Among the numerous cases of mistaken identification through fingerprinting, that of Brandon Mayfield is particularly indicative. Following the Madrid bombings of March 11th 2004, Spanish National Police managed to lift a fingerprint from an unexploded bomb. Three highly skilled FBI fingerprint experts declared that Oregon lawyer Brandon Mayfield's fingerprint was a match to the crime scene sample, describing the match as "absolutely incontrovertible" (Washington Post, 2004). As a former U.S. soldier, Mayfield's fingerprint was on the national fingerprint system. Mayfield was imprisoned for two weeks. The fingerprint, however, was not his. Mayfield was himself a convert to Islam who had once represented a convicted Taliban sympathizer in a child custody dispute. So when Mayfield's personal information was combined with the crime scene evidence, the FBI was convinced of his culpability. The cautionary tale is that as the collection of biometric information increases, and as it moves from law enforcement to civilian applications, the error rate may significantly increase.

- *Individuals may have a negative attitude towards providing their biometrics.* People may be reluctant to place their fingers on the scanners due to hygiene concerns. More importantly, there is the widespread public perception that fingerprinting is linked to the criminal justice process. Related, in conflict affected countries stricken by ethnic infighting, individuals may refuse to provide biometrics for fear of persecution by authorities or others that gain illegal access to such biometric records. Finally, during the Parliamentary debates concerning the ID Cards Bill in the UK, 55 per cent of respondents of a poll thought that the collection of biometric information was an infringement of civil liberties. In Malawi, the authors did not encounter any resistance from the farmers, perhaps because it was a very novel technology.

- *The cost of collecting biometrics can be high.* The estimates are sparse and detailed cost-benefits analyses have not been systematically conducted. However, the costs of using different types of biometric technology starting from basic fingerprinting techniques to voice

[8] The equal error rate (EER) refers to the point at which FMR equals FNMR.

and iris recognition software can be prohibitively expensive. In India there are legitimate concerns that the costs of rolling out biometric technology may mean a huge opportunity cost for the provision of social benefits for over 700 million Indians living in poverty. In the UK, a critical report by several researchers at LSE found that the government underestimated the implementation of the ID Cards Bill. The report suggests that the ten-year rollout would be between £10.6 billion and £19.2 billion, excluding public or private sector integration costs.

- *Biometric technology is not infallible.* While biometric technology can be big step forward to combating issues of identity theft, fraud, and money-laundering efforts, it is essentially a technological application. As is the case with any other technology, it can be hacked, infiltrated, or runs the risk of having data fall into the wrong hands. Since biometric technology in only at present being piloted on a large scale in some pockets of the world, legitimate concerns on privacy do arise. For example, it is possible to imagine that workers on the ID database will be corrupted, threatened or blackmailed. After all, the perpetrators of 80 per cent of all computer security lapses are not hackers, but employees. Optical scanners that use minutiae-based and pattern-matching technologies such as the ones in the Malawi pilot have been tricked into accepting reactivated latent prints or artificial fingers with forged fingerprints. Latent fingerprints were reactivated by simply breathing on the sensor or by placing a water-filled plastic bag on the sensor's surface. Latent fingerprints could also be reconstructed and authenticated by dusting the sensor's platen with commercially available graphite powder and lifting with adhesive tape. Artificial fingers made with candle wax or gelatin and the fingerprints of enrolled individuals have also successfully fooled the system (Thalheim et al. 2002).

- *It is important that a common platform is used if biometrics data is merged with other datasets.* Biometric data is stored in formats that may not be compatible with the information systems of other government agencies so an effort must be made to have compatibility if it has to serve as the basis for a national identification system.

5. Conclusions

Biometric technology presents a valuable data capture interface but it is only a technology. As such, it alone cannot be the panacea for all government and market inefficiencies. It even doesn't resolve by itself the challenges inherent in building identification systems, as other factors affect data quality. Even countries with national ID forms of some sort struggle constantly with compliance of data providers, with data information sharing laws, regulations or simple industry codes of conduct.

But despite these concerns, biometric technology presents an exciting and innovative opportunity for increased access to financial markets and better public service delivery. Whether it can be

scaled up effectively and be used to resolving identification and authentication issues remains to be seen.

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