

Banknote Substrate Durability: A live circulation comparative study

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Abstract—Banknotes is a concern of central banks and banknotes suppliers. Durability of a banknote depends on several factors. This paper aims at presenting a live circulation trial, considering a set of well-known substrates in the market, in addition to the impact of varnishing, intaglio and climate variations and public habits.

Keywords—Banknotes durability; Substrates; Varnishing; Intaglio

I. INTRODUCTION

Banknotes Technical specifications in central banks are generally based on two pillars: Security and Durability [1]. Durability is the period of time in which a circulated banknote is still in good conditions for circulation with respect to the fitness criteria of the central bank. Banknotes continue to circulate, if a returned banknote, to the central bank, does not meet the fitness criteria, then it is taken out of circulation and destroyed [2]. The most important factors affecting the durability of the banknote are: The substrate treatment, the climate and the public habits in handling banknotes [1]. The durability varies by banknote denomination. Lower denominations have higher velocity than higher denominations and are more often used for transactions [2] Banque du Liban (BDL) the central bank of Lebanon has launched a research project aiming at studying the evolution of a banknote with time and at measuring its durability.

The project consists of putting into circulation 11 million banknotes of the lowest denomination (1000 LBP) along with the existing banknotes in circulation from the mentioned denomination. The trial banknotes, have the same design of the banknotes in circulations, belongs to 11 groups representing several substrates, varnishing and intaglio printing. The table in Figure 1 shows the 11 groups of trial banknotes representing 7 well known substrates and a variation of varnishing and intaglio printing.

BDL has 9 branches deployed in all Lebanese territories from north to south and from the coast to Bekaa Valley. The head office of BDL is the exclusive cash center, in Lebanon for Lebanese pound. In fact, all deposited banknotes, in all

branches are transferred to the head office for counting and sorting.

	Unvarnished	Cationic UV Cured	Single side Intaglio	Double side Intaglio
Traditional cotton	X		X	
Traditional cotton	X			X
Traditional cotton		X	X	
Traditional cotton		X		X
AST™ - Crane Currency		X		X
Diamone – Arjowiggins Security		X		X
Long life – Papierfabrik Louisenthal		X		X
Platinum – DeLaRue		X		X
High durable chemical treated paper - Goznak		X		X
Hybrid - Papierfabrik Louisenthal		X		X
SRT – Landqart AG		X		X

Figure 1:11 groups of trial banknotes representing 7 substrates and a variation of varnishing and intaglio printing

Counting and sorting operations are performed at the head office, cash operations department, where the cash center is equipped with five M7 machines capable to capture the serial number of each banknote.

Lebanon is located on the eastern edge of the Mediterranean and characterized by its geographical and weather diversity.

Contained within its borders are three different topographical and climate zones: a narrow coastal plain, the inland peaks of Mount Lebanon and the Bekaa plateau (Figure 2). Lebanon's climatic conditions are determined by its geography and physiography. They vary from a Mediterranean climate along the coastal plain and in the middle mountain range, to reach sub-alpine or mountain Mediterranean climates on the highest slopes, covered by snow during most of the year; it becomes sub-deserted and almost too dry for agriculture in some of the northern plains [3].



Figure 2: different topographical and climate zones in Lebanon

In addition to the climates variation in Lebanon, one more factor affecting the durability of the banknotes, is the way of the public are dealing with banknotes and the public habits in different Lebanese regions (Figure 3)



Figure 3: Public habits in dealing with banknotes

The branches of BDL are deployed in the mentioned three different regions. Deposited banknotes on the branches are transferred to the head office in special containers called *Cash boxes*. A cash box is a transparent containers equipped with an RFID tag, where registered information indicating the type of the box (expressing the value of its contents) and the branch (i.e. the region) source. Therefore, all Lebanese banknotes counting and sorting operations are centralized in the unique cash center at BDL head office, where all data are collected in a database and special report are used for data analysis.

This paper presents a proposition of a live circulation trial of banknotes aiming at measuring the durability of a banknote. The proposition is based on studying the evolution, with time, and the durability of 11 million banknotes, from the lowest denomination, in circulation. The 11 million banknotes represents the same design but different substrates, varnishing and intaglio printing techniques. In addition to substrates and printing techniques, the proposition considers the public habits in dealing with banknotes and the climate variation and all its consequences related to unfit reasons of the banknote: soiling, humidity, and etc.

The source of data analysis and interpretations are, from one hand the database of serial number reading on M7 machines and on the other hand, the laboratory testing of samples from the trial banknotes at the Lebanese Atomic Energy Commission where results shows, periodically, the evolution of the banknote in terms of ink thickness, fibers status, and other substrates specifications

II. STATE OF THE ART

Increasing banknotes durability has been the aim of several works in the literature. In [4], a trial has been conducted by the bank of England on the 5£ to test a feature designed to retard soil absorption and the propagation of edge tears. The trial shows the decrease of crackle and soil ratio with time after using varnishing and coating techniques. A trial has been done on 4 different substrates shows that soiling is the main reason for classifying banknotes from circulation unfit [1]. An interesting numerical model, using gamma distribution, to estimate life-length of banknotes is presented in [6] with a case study at Bank of Netherlands. The paper presents numerical models for each stage of banknote life: Issue and withdrawal, sorting procedure, circulation and return to the bank. A circulation trial, in bank of Colombia, shows the improvement of banknote durability after varnishing [5]. This work considers two groups for trial: 600000 varnished banknotes and 600000 unvarnished banknotes (Control group). However the author mentioned that the trial period was 11 month where the number of unfit varnished banknotes is 333930 and 463351 unfit unvarnished banknotes. The analysis of the results uses the linear regression approach to estimate the number of months of the total quantity (600000) from each group. Nevertheless, the life of banknotes in circulation is represented by the survival curve as mentioned in [5] and [7].

All the above works are interesting and present efforts in increasing the durability of the banknote.

In this paper, BDL presents a proposition for a live trial of 11 million banknotes representing different substrates and considering the impact of varnishing and intaglio printing. The data analysis will consider the climate variation and the public habits in dealing with banknotes.

III. PROPOSITION

As mentioned in the introduction, our proposition aims at measuring the durability of banknotes in circulation and issued with several substrates, and to study the evolution, with time, of the banknote. To reach the expected results, the following elements have been prepared:

- *Serial number reading on BPS M7 machines:* BDL has designated to this project, two identical BPS M7 machines with identical settings for all sensors. BPS M7 are processing banknotes and reading the SNR, comparing SNR against predefined list and storing all the SNR in the machine HDD for Two groups of banknotes are defined for each machine:
 - Black list: Particular Banknote whose match is found in the SNR list should be rejected for manual inspection.
 - White list: Particular Banknote whose match is found in the SNR list should be stacked (as fit) or shredded online.

Black list and whit list sets contains serial numbers of banknotes from the 11 banknotes trial groups.

- *Database and reporting system:* a database has been created to manage all information related to trial banknotes: serial number, type, date of circulation, geographical region, unfit reasons, in addition to the data collected from the M7 machines: serial number, date of reading, banknote properties, and the coming from region.

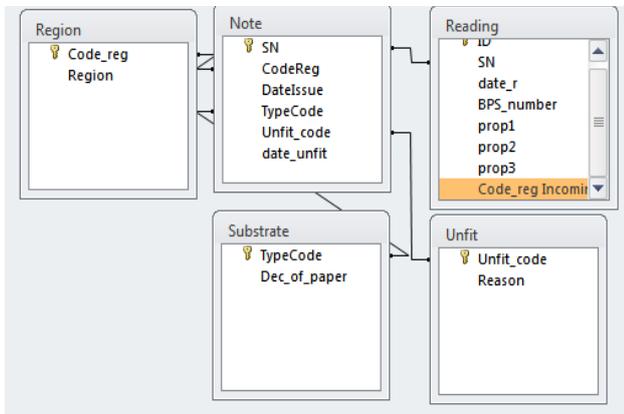


Figure 4: SNR database schema

Several reports can be generated for data analysis, for instance:

- The circulation date, the shredding (unfit) date of each banknote from each trial group. Therefore it is possible to measure the durability of banknotes from different substrates and show the impact of varnishing and intaglio printing.
- For each trial banknote is registered, the number of reading (number of times returned to central bank) the properties (features). This info is useful to study the evolution of the banknote with time.
- Banknotes from black list set will be sent to the laboratory of Lebanese Atomic Energy Commission for advanced testing to check the thickness of ink, the fiber status, and etc. after each time a specific banknote is returned to BDL.
- The correlation between unfit reason, banknote properties and the geographical region, therefore the effect of climate variation on different substrates.

IV. CONCLUSION AND FUTURE WORK

The project has been launched, all the technical requirements are being finalized, BDL is expecting to start the live circulation experiments after receiving the trial banknotes from the printing company.

We believe that the results that will be published in the future work, will be beneficial for the banknote industry as well as for the central banks.

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