Optimizing Cash Management for Large Scale Bank Operations

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ABSTRACT

The Federal Reserve System (Fed) provides currency services to banks, including sorting currency into fit and non-fit bills and repackaging bills for redistribution. To reduce the cost of currency management operations, many banks make Fed deposits and withdrawals of the same denomination each week. In July 2007, the Fed introduced fees for making both deposits and withdrawals during a given Monday through Friday. Recognizing an opportunity, Fiserv Corporation initiated a project to optimize bank vault inventories across time and space. This article presents the integer programming model developed to assist Fiserv clients reduce the logistics cost component of cash management. The model is implemented in software using OPL. The underlying configuration is a time-space multi-commodity network with a fixed-charge cost structure. The authors report on a successful pilot study and present an efficient heuristic procedure that can be used to reduce computational solution times from hours to a few minutes.

Keywords: Financial Models, Heuristics, Optimization Methods, Planning Models

INTRODUCTION

The major banks in the United States own cash distribution centers called vaults. A vault is a large warehouse with no windows and lots of security. Deposits and withdrawals are made using armored vehicles carrying millions in cash. Vaults contain equipment that counts, sorts, and packages currency for redistribution. The fit currency can be distributed to their branch banks, can be used to supply ATMs, or can be returned to the Fed. Currency that is determined to be unfit for further circulation is returned to the Fed for destruction. Large national banks have created a network of cash warehouses (vaults) to manage their cash requirements.

Vaults may experience either a deficit or a surplus of currency of the various denominations. In the past, the Fed supplied deficits and accepted surplus cash from the various vaults at a nominal fee. Beginning in July 2007, the Fed imposed penalties on certain types of cash transfers called cross-shipping fees. Since counterfeit bills are usually 100s and 50s, these were excluded from cross-shipping fees. That is, the Fed wants to continue frequent checks of these denominations so that counterfeit bills

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could be quickly removed from circulation. For other denominations, cross-shipping fees apply when both an order and a deposit occur during the same week. That is, placing an order for 20s on Monday and making a deposit of 20s on Thursday results in a cross-shipping fee on the smaller of the two transactions.

In order to help the vaults avoid excessive cross-shipping fees, the Fed allows a vault to designate a certain area with a given capacity for what is known as custodial inventory. Any currency placed in custodial inventory belongs to the Fed but is physically located at the vaults. The advantage to the vault is that this currency has been taken off the books of the vault and essentially returned to the Fed. In addition, the Fed excuses a certain amount of cross-shipping without penalty during each quarter. This value is known as de minimus (Fedfocus, 2007). Suppose de minimus is 20 million for a given vault. Then no cross-shipping penalty is paid until the 20 million in cross-shipping transactions is exceeded during the current quarter.

Fiserv Corporation is a major player in banking software. One of their products, iCom, helps banks manage the logistics of cash with respect to vaults, branches, and ATMs. In 2005 they began to develop a new module that would optimize logistical operations at vaults under the new cross-shipping environment to be imposed in the summer of 2007. This manuscript presents the linear multi-commodity integer programming model developed to support the logistical operations of their clients. This model is written in OPL 5.0 (http://www.ilog.com/products/oplstudio/) and uses the CPLEX 10.1 (http://www.ilog.com/products/cplex/), solver. The optimization model was implemented as a new module within iCom and was used in a six month pilot study by one of their bank clients. Since computational time is a major issue for this project, we also developed a new heuristic that mitigates the computational time issue.

Due to the different possible combinations of cash transfers that can occur, certain assumptions were made in the model. Any cash transfer from the Fed on a particular day is available at the vault on the same day for distribution. A cash transfer between vaults on the same day implies the cash is available at the destination vault on that day. A one day cash transfer between vaults implies that the money is available on the very next day at the destination vault for distribution. The upper bound on the bundles of cash that can be transferred is infinity, i.e. there are always trucks available for cash transfers. The variable cost on cash transfers is linear.

**SURVEY OF LITERATURE**

The use of optimization models to assist management in the area of cash management dates back to the 1960s. Orgler (1969) presents a multi-period linear programming model for cash management. Decisions regarding payments, short-term financing, the cash balance, and securities transactions are variables in his model. He attempts to maximize revenues over the planning period subject to institutional business rules. One unique feature of his model is the use of unequal length planning periods. Hence, a one-year model can begin with daily transactions and end with monthly transactions.

Constantinides (1976) uses stochastic calculus to analyze a special cash management problem with stochastic demand. He attempts to minimize the expected cost in the time interval $[0,T]$ as $T$ goes to infinity. Several special cases are analyzed in his exposition. An extension of this work may be found in Constantinides and Richard (1978). They formulate a cash management model for a single entity (such as a bank or retail outlet) where the demand for cash in a given time interval is given by a random variable. Their model uses fixed and variable costs for transferring funds as well as a holding-penalty cost for maintaining the given cash balance. They provide a policy analysis for a manager who continuously monitors the cash position and only intervenes at optimal points in time.

Mensching et al. (1978) consider a cash management problem using techniques from inventory theory. Their model is a determinis-
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