Optimizing Healthcare Flexible Spending Account Contributions Using Inventory Management Theories: An Interdisciplinary Study

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The healthcare Flexible Spending Account (FSA) offers employees significant tax benefits by allowing the use of pre-tax funds for healthcare expenses, but it also carries the risk of forfeiting unspent funds. To address the challenge of maximizing tax savings while minimizing the risk of forfeiture, this study applies inventory management and economic theories to develop a heuristic for optimizing FSA contributions. Both basic and extended versions of FSAs are examined, alongside the impact of marginal tax rates on decision-making. A simulation model demonstrates the effectiveness of the proposed heuristic, with results showing minimal deviations from the optimal solutions—less than 0.42% for the basic version and 3.11% for the extended version, and performance differences of less than 0.005% and 0.08%, respectively. By integrating operations management, economic theories, and personal finance research, this study introduces a novel decision-support tool for optimizing FSA contributions, while also laying the groundwork for future research in this interdisciplinary field.

Keywords: flexible spending account, healthcare finance, risk management, inventory management, optimization, personal finance planning

INTRODUCTION

A flexible spending account (FSA) is an employee benefit for tax saving and healthcare financing. Provided by employers, FSAs enable employees to allocate pretax money into their accounts for future qualified healthcare expenses, including medical drugs, devices, prescription eyeglasses, contact lenses, and more. The primary advantage of FSAs is their exemption from both income and payroll taxes. During an annual open enrollment period, typically at year-end, employees must determine their contribution amount, which cannot be adjusted until the next enrollment period a year later. Any unused funds within a specific timeframe will be forfeited (use-or-lose).

Due to the use-or-lose nature and restrictions on changing contribution amount during the year, participating employees are exposed to at least two types of risks. On the one hand, if the contribution amount is too high, employees face a significant high risk of forfeiting unused funds. On the other hand, if the contribution amount is too low, employees must cover healthcare expenses using after-tax dollars, which more costly than pre-tax dollars. These risks, combined with the lack of effective decision support tools available to employees, have resulted in consistently low participation rates of FSAs (Cardon, Denning, & Showalter, 2013; McLeese, 2014). Additionally, only 16% of the participants contribute the right yearly amount (FSAStore, 2024). Therefore, the primary challenge is determining the optimal contribution amount to FSAs.

Despite the importance and challenges of this issue for individual employees and policymakers, there has been little research on this topic. While some personal finance magazine articles have acknowledged the difficulties faced by FSA holders, they primarily focus on strategies for quickly spending funds when the deadline is approaching rather than optimizing contribution decisions during open enrollment. This is the first study to apply inventory management theories to address FSA contribution challenges. We propose a theory-based heuristic that can be easily implemented and requires minimal analytical knowledge. This simplicity makes it accessible to a large population, including those without advanced computational skills.

The rest of the paper is organized as follows: Section 2 defines the problem and the relevant variables. In Section 3, we propose our heuristics based on inventory management theories. To implement and evaluate the proposed heuristics, we develop a simulation model in Section 4 and use it to conduct the experiments across multiple scenarios in Section 5. Finally, we discuss our conclusion and future research directions in Section 6.

PROBLEM DEFINITION

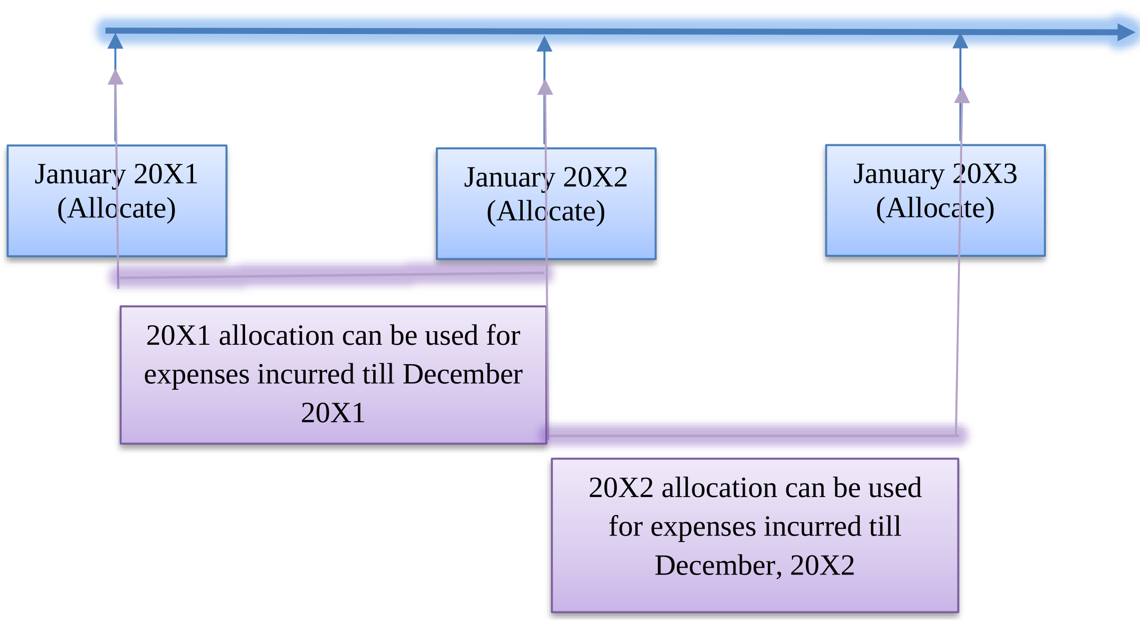
In this section, we will first introduce the two versions of FSAs: basic version and the extended version. Following it, we will define the problem and outline the variables used in the model.

Basic Version and Extended Version of FSAs

Basic Version

In some companies, the contributed dollars must be spent within the calendar year without a grace period. This situation is considered as the base case. In the basic version, any unused funds will expire at the year-end. The mechanism of this version is illustrated in Fig. 1. The contribution decision is made on December 31 and any unused fund will be forfeited at the next December 31.

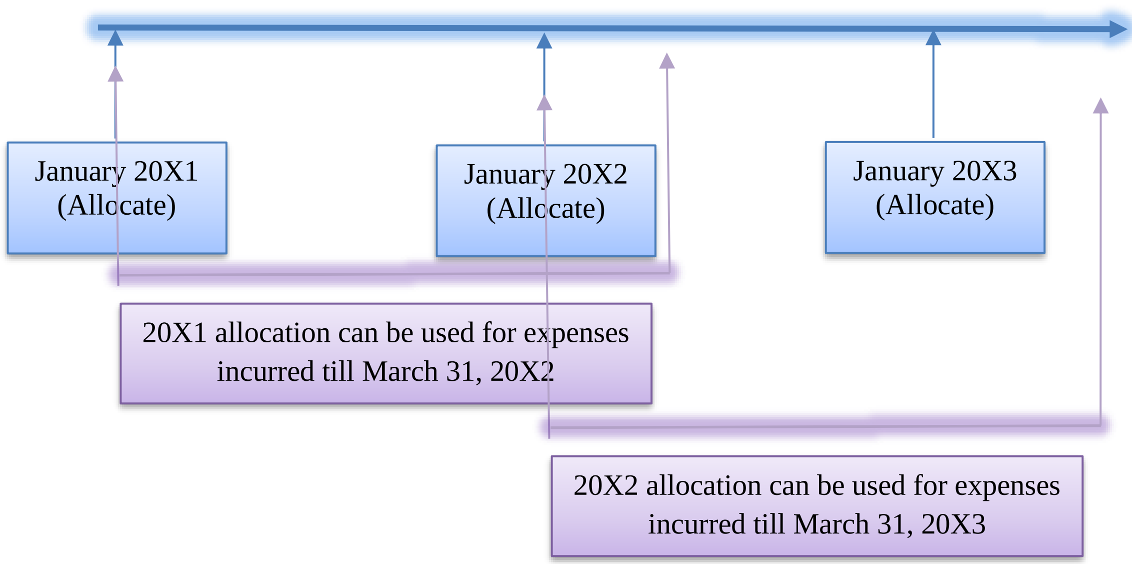
FIGURE 1
MECHANISM OF BASIC VERSION FSAS



Extended Version

To encourage employee participation in the FSA program, the Treasury Department significantly modified in 2005 to reduce forfeiture risk. This change allows FSA holders to use their funds until March 15 of the following year (Cardon et al., 2013). The mechanism of the extended version is illustrated in Figure 2. During the grace period (the first quarter of the year), FSA holders have access to two pools of funds: the unused funds from the prior year and the newly contributed amount for the current year.

FIGURE 2
MECHANISM OF EXTENDED VERSION FSAS



Problem Definition and Variable Descriptions

Because the key decision points and event timeline follow quarterly patterns, we analyze four quarters for the basic version, and five for the extended version. For the extended version, the exact expiration date is March 15, which is approximately the end of the first quarter for modeling convenience. Without loss of generality, we assume that the qualified healthcare expenses in each quarter follow a normal distribution with an expected value μ and a standard deviation σ. Due to the tax-saving nature of FSAs, we analyze the impacts of marginal tax rate τ by considering its different levels. The marginal underage cost is C_u and the marginal overage cost is C_o. We aim to find the optimal order up-to-level, UTL, which represents the target value of the fund at the beginning of the year. This order-up-to policy has been proven to be optimal in the literature and will be further discussed in the heuristic development section.

Therefore, the objective function of this problem is to minimize the expected total annual expense T by optimizing the decision on the up-to-levels (UTL). Here, total annual expense T is the sum of the contributed amount D and the extra out-of-pocket expense P, formulated as Min $T = P + D$. The parameters and variables used in this model are listed in Table 1.

TABLE 1
PARAMETERS USED IN THIS MODEL

Variables	Descriptions
n	Number of the quarters in analysis (4 for the basic version and 5 for the extended version)
μ	Expected quarterly expense
σ	Standard deviation of quarterly expense
τ	Marginal tax rate
C_u	Cost of underage, shortage cost per dollar
C_o	Cost of overage, expiration cost per dollar
UTL_B	Up-to level, the target value at the year beginning, for basic version
UTL_E	Up-to level, the target value at the year beginning, for extended version
P	Average extra payment per year
D	Average deposit per year
T	Expected total expense per year (= P + D)

HEURISTIC DEVELOPMENT

To address this FSA contribution problem, we propose an effective heuristic based on the optimization theories from inventory management literature, particularly those concerning perishable items. This FSA funding problem parallels the *periodic review*, *lost-sales*, *perishable* inventory problem. The cash in FSA account behaves like *perishable* inventory because it expires and is forfeited at a fixed day. And the FSA problem aligns with the annual *periodic review* policy since employees can only replenish their funds once a year at the year-end. Moreover, it resembles a *lost-sales* case because the healthcare expense must be immediately covered and cannot until the fund is replenished later. These comparative characteristics are summarized in Table 2.

TABLE 2
COMPARATIVE CHARACTERISTICS OF FSA FUNDING AND INVENTORY MANAGEMENT PROBLEMS

FSA funding problem	Inventory management problem
Use-or-loss at the expiration day	Perishable product
Fund FSA once a year	Annually periodic review policy
Health care cost must be paid immediately	Lost sales, no backorder

Therefore, this FSA fund problem can be viewed as analogous to a periodic review inventory management problem with perishable products and no backorder. For this inventory problem, order-up-to policy has been proven to be optimal. Since no lead time is involved in this FSA problem, it simplifies to a classic newsvendor problem (Huh, Janakiraman, Muckstadt, & Rusmevichientong, 2009).

Newsboy Inventory Management Policy

The newsboy problem is described as follows: at the beginning of the day, the newsboy purchases newspapers from the publisher at a unit cost c, and during the day, he sells them at a price p to customers whose demand is random. Any unsold items are recycled with a unit salvage value s. Here $p > c > s$. The newsvendor's problem is to decide how many copies of the newspaper he should purchase at the beginning of the day to maximize the expected profit. On the one hand, if he buys too many copies, the unsold newspaper has very little value at the end of the day. On the other hand, if he buys too small, he may run to shortage situation and lose.

In the inventory management literature, this problem is called a single period stochastic inventory problem, which determines the quantity of products to order by a vendor facing stochastic demand over a short selling season (Nahmias, 2008; Zhang & Bell, 2007). Since the pioneering works of Arrow et al. (1951) and Morse & Kimball (1951), the classic single-period inventory problem with stochastic demand, commonly referred to as the newsvendor or newsboy problem, has attracted much attention. It is focused on ways to deal with demand uncertainty for products that are perishable, seasonal, or have a short life cycle (Chung, Flynn, & Zhu, 2009; Fisher, Hammond, Obermeyer, & Raman, 1994).

The solution to this newsboy problem is provided as follows: the optimal purchase quantity q* is the smallest q such that, $F(q) \geq \frac{C_u}{C_u+C_o}$, where C_u is the cost of underage, C_o is the cost of overage, and F is the distribution (cumulative distribution function) of the random demand X. When the random variable X is continuous, $q^* = F^{-1}\left(\frac{C_u}{C_u+C_o}\right)$ (Chopra & Meindl, 2015).

Heuristics for the Basic Version of FSA

Without loss of generality, we assume that the quarterly healthcare expenses follow a normal distribution, $Normal(\mu, \sigma)$. The heuristic can be modified for other distributions with minimal effort. According to the newsvendor inventory model, the optimal order-up-to-quantity corresponds to the inverse function of the Normal distribution.

$$UTL = NORMINV\left(\frac{C_u}{C_u + C_o}, 4\mu, 2\sigma\right)$$

Next, we determine C_u and C_o respectively. The cost of underage occurs when the actual healthcare expense exceeds the available funds. In this case, the employee loses the tax-saving opportunity, and the cost of underage C_u is the difference between using pre-tax dollar and after-tax dollar. Because one pre-tax dollar is equivalent to $1 - \tau$ after-tax dollar, the difference is as follows.

$$C_u = 1 - (1 - \tau) = \tau$$

The cost of overage occurs when the actual healthcare expense is lower than the available funds, and the remaining funds are forfeited. In that case, the loss is one pre-tax dollar, or in terms of after-tax dollar, $C_o = 1 - \tau$. Thus,

$$\frac{C_u}{C_u + C_o} = \frac{\tau}{\tau + (1 - \tau)} = \tau$$

Therefore, the heuristic of finding the optimal contribute up-to level (*UTL*) is:

$$UTL_{Basic} = NORMINV\left(\frac{C_u}{C_u+C_o}, \mu, \sigma\right) = NORMINV\ (\tau, 4\mu, 2\sigma) \quad (1)$$

where

- τ is the marginal tax rate of the employee
- μ is the average healthcare expense per quarter
- σ is the standard deviation of the healthcare expense per quarter

In the above analysis, we used after-tax dollar as the base, but the results should remain the same if pre-tax dollar is used. In the case of using pre-tax dollar as the base, because one after-tax dollar is equivalent to $\frac{1}{1-\tau}$ pre-tax dollar, we get:

$$C_u = \frac{1}{1-\tau} - 1 = \frac{\tau}{1-\tau}$$

The cost of overage is the loss is one pre-tax dollar, $C_o = 1$. Thus,

$$\frac{C_u}{C_u + C_o} = \frac{\frac{\tau}{1-\tau}}{\frac{\tau}{1-\tau} + 1} = \tau$$

Therefore, the heuristic formula (1) remains the same regardless of whether pre-tax or after-tax dollars are used as the base.

Heuristics for the Extended Version of FSA

The extended version of FSAs allows employees to use their contributed funds over one year plus an additional quarter. Instead of four quarters, the analyzed time horizon of the extended version covers five quarters. This extension introduces a problem that blends the characteristics of both 4-quarter and 5-quarter newsvendor problems.

We begin developing heuristics by finding the bounds of the optimal solutions. For the lower bound, since the extended policy reduces the risk of losing unexpended fund, employees have more incentive to increase the fund amount. Therefore, this version's contribution up-to-level (UTL) should be higher than the one without the extension allowance. In other words, we can use heuristic solution from the basic version as the lower bound of this problem. Based the results of the basic version, we get the lower bound of *UTL* as follows.

$$UTL_{Lower} = NORMINV\ (\tau, 4\mu, 2\sigma) \quad (2)$$

For the upper bound, the optimal contribution amount should be lower than that for a five-quarter newsvendor problem. In a five-quarter newsvendor problem, decision-making must wait until the end of the fifth quarter. However, in the extended version, employees can decide on the new contribution at the beginning of the fifth quarter. This incentivizes employees to wait later to add more fund, rather than contributing the expected expenses for all five quarters at once. In order words, the optimal *UTL* for a five-quarter newsvendor problem serves as the upper bound of the optimal solution of this extended version.

$$UTL_{Upper} = NORMINV\left(\tau, 5\mu, \sqrt{5}\sigma\right) \quad (3)$$

Based on the above analysis of the extended version and the results of the lower and upper boundaries, we propose that the *UTL* of this extended version is the average of these two boundaries (2) and (3):

$$UTL_{Extended} = \frac{UTL_{Lower} + UTL_{Upper}}{2} \quad (4)$$

NUMERICAL EXPERIMENTS USING SIMULATION MODEL

Assumptions and Data Used in Simulation

In this simulation, we assume that there are 360 days in a year and 90 days per quarter. Contribution decisions are made on December 31. The amount of quarterly healthcare expenses follows a normal distribution with a mean of 300 and a standard deviation of 50. All unused funds are forfeited at the expiration day, which is December 31 for basic version and March 31 for extended version.

Each simulated year, the system generates one entity representing one year for a person. By setting "halt simulation at limit" to 100, the simulation includes 100 entities in per trial, which simulates 100 years of data for a person. The system runs 200 trials to collect data of 200 persons. Additionally, to investigate the impacts of tax rates on this decision-making problem, the experiments are designed and analyzed at different marginal tax rates of 15%, 20%, 25%, 30%, 35%, and 40%.

Description of the Simulation Design

In this section, we describe the simulation design step by step. Here the extended version is focused because it can be easily modified for the basic version, which is described at the end of this section. The simulation design is summarized in a flowchart (Figure 3).

- *The beginning of this year*

  At the beginning of the year, if any unspent money is left from the prior year, it is labeled as Money 0, meaning "old" money, and it has a higher priority to be spent in the first quarter of the current year. At the same time, decision-makers will replenish the total amount in the FSA to the up-to-level, and the newly contributed money (Money 1) has a lower priority to be spent in the first quarter of this year.
- *Quarter 1: The first quarter of the current year and the fifth quarter of the prior year*

  During the first quarter, which serves as the first quarter of the current year and the fifth quarter of the prior year, healthcare expenses are paid using the money left from the prior year (Money 0) first. If Money 0 is insufficient, the newly contributed amount (Money 1) is used. If Money 1 is insufficient, employees must cover the remaining expenses using their out-of-pocket after-tax funds.
- *The end of Quarter 1*

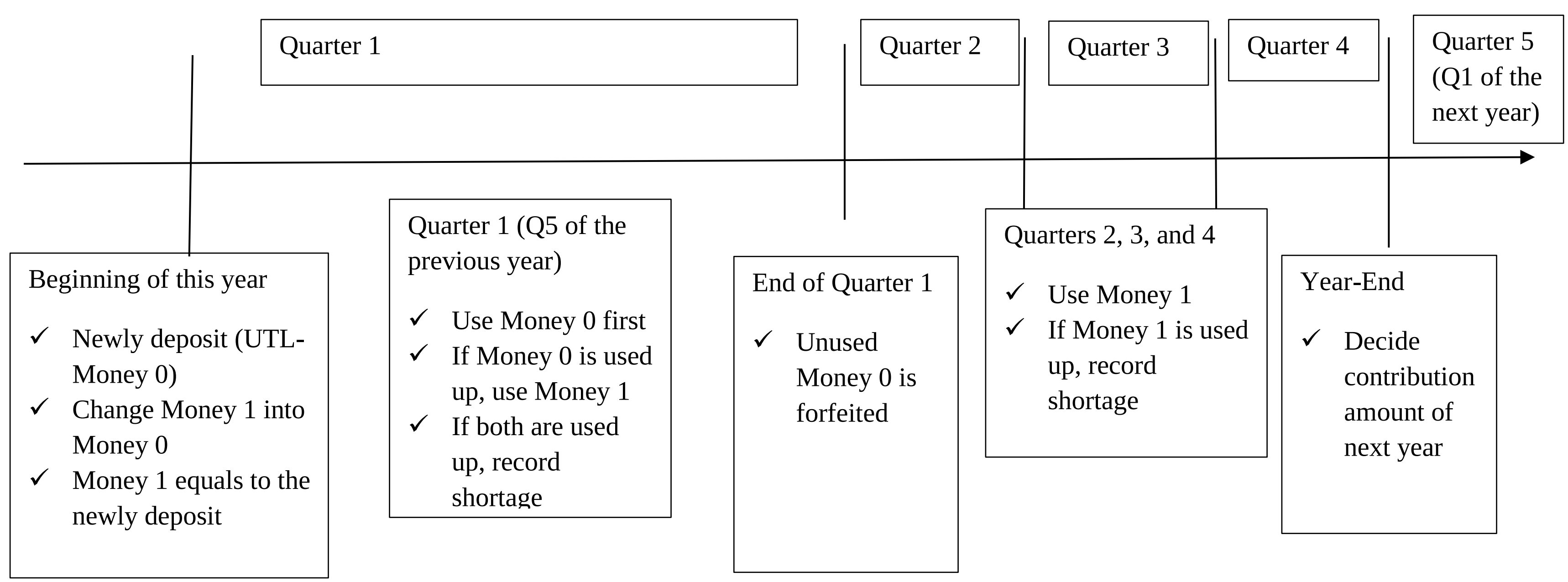
  At the end of the first quarter, according to the FSA policy of the extended version, any remaining money from the previous year (Money 0) expires and is forfeited.
- *Quarters 2, 3, and 4*

  During Quarters 2, 3, and 4, the healthcare expenses are paid using Money 1. If Money 1 is inefficient, employees must use their after-tax money to cover the healthcare expenses.
- *The End of the Year*

  In the basic version, the leftover in the account is forfeited at the year-end. The remaining amount is carried over to the next year in the extended version. The decision to make new contributions is based on the up-to-level policy.

  Although the described model is for the extended version of FSA polices, it can be easily modified for the basic version, where only Money 1 is used and expires at the end of each year. Since Money 0 is not considered, the simulation process in the first quarter is identical to that in quarters 2, 3, and 4, resulting in a total analyzed horizon of four quarters rather than five in the extended version.

FIGURE 3
THE FLOWCHART OF THE SIMULATION DESIGN



RESULTS AND ANALYSIS

Basic Model and the Results

In the basic model, the fund in the FSA must be used within the year. This means there is only one type of money, referred to as Money 1. By applying the proposed heuristic, the optimal contribution up-to level (UTL) is calculated using the formula $NORMINVERS\ (\tau, 300 \times 4, 50 \times \sqrt{4})$. For each value of marginal tax rate (τ), Table 2 lists the corresponding optimal up-to levels and their performance in terms of annual expenses.

TABLE 2
OPTIMAL RESULTS PROVIDED BY THE PROPOSED HEURISTIC FOR BASIC MODEL

τ	Heuristic Optimal UTL	Average Extra Payment (After-tax) $/year	Average Deposit (After-tax) $/year	Expected Total Expense (After-tax) $/year
15%	1096	112.92	940.92	1,053.83
20%	1116	96.16	901.73	997.89
25%	1133	82.81	858.25	941.06
30%	1148	71.81	811.64	883.45
35%	1161	62.93	762.20	825.13
40%	1175	54.27	711.85	766.12

It is noted that with the optimal UTLs, all the expected total expenses are significant lower than the expected annual healthcare expense of $1,200. The higher the marginal tax rate, the more significant the saving effect. For instance, if an individual's tax rate is 40%, participating in FSA with optimal contribution amount could save $433.88 per year (calculated as $1,200 - $766.12).

Next, we use a simulation model to search for the optimal UTL for comparison purposes. The search is centered around the expected annual demand of $1,200, extending from $1,050 to $1,300 in increments of $10. The optimal UTLs for different values of the margin tax rate (τ) are reported in Table 3. Additionally, the performance of each optimal UTL is detailed in Table 3, including the average extra payment per year, average contribution per year, and the expected total yearly expenses.

TABLE 3
OPTIMAL RESULTS PROVIDED BY THE SIMULATIONS FOR THE BASIC VERSION

τ	Simulation Optimal UTL	Average Extra Payment (After-tax) $/year	Average Deposit (After-tax) $/year	Expected Total Expense (After-tax) $/year
15%	1,100	109.49	944.35	1,053.83
20%	1,120	92.94	904.96	997.90
25%	1,130	85.10	855.98	941.07
30%	1,150	70.40	813.05	883.45
35%	1,160	63.59	761.54	825.13
40%	1,180	51.08	715.08	766.16

To compare the results from our heuristic method and those from the simulation optimization method, the comparative results are reported in Table 4. Given that the simulation searching increments are in $10 steps, the difference in optimal UTLs obtained by heuristic and simulation methods is equal to or less than 0.42%, and the performance difference is equal or less than 0.005%. Therefore, the proposed heuristic method provides similar results while requiring significantly less effort.

TABLE 4
SUMMARY OF THE COMPARATIVE RESULTS FOR THE BASIC VERSION

	Optimal UTL			Total expenses (After-tax)		
τ	**Heuristic**	**Simulation**	**Difference in percentage**	**Heuristic**	**Simulation**	**Difference in Percentage**
15%	1,096	1,100	0.36%	1,053.83	1,053.83	0.0000%
20%	1,116	1,120	0.36%	997.89	997.90	0.0011%
25%	1,133	1,130	0.27%	941.06	941.07	0.0018%
30%	1,148	1,150	0.17%	883.45	883.45	0.0007%
35%	1,161	1,160	0.09%	825.13	825.13	0.0004%
40%	1,175	1,180	0.42%	766.12	766.16	0.0050%

Extended Model and Results

Applying the proposed heuristic for the extended version, as presented in formulas (2), (3), and (4), to this numerical example, we derive the following formulas to find the optimal UTL for extended version of the FSA problem.

$$UTL_{Extended} = \frac{UTL_{Lower} + UTL_{Upper}}{2}$$

where
$$UTL_{Upper} = NormalInvers\ (\tau, 300 \times 5, 50 \times \sqrt{5})$$
$$UTL_{Lower} = NormalInvers\ (\tau, 300 \times 4, 50 \times \sqrt{4})$$

Using the above heuristic, we determine the optimal UTL for different values of the marginal tax rate (τ). The performance of each optimal UTL is reported in Table 5, including the average extra payment per year, average deposit per year, and the expected total expense per year.

TABLE 5
OPTIMAL RESULTS PROVIDED BY THE PROPOSED HEURISTIC FOR THE EXTENDED VERSION

τ	Heuristic Optimal UTL	Average Extra Payment (After-tax) $/year	Average Deposit (After-tax) $/year	Expected Total Expense (After-tax) $/year
15%	1,240	23.12	1,011.48	1,034.60
20%	1,261	10.77	962.81	973.59
25%	1,279	112.61	824.66	937.27
30%	1,294	1.66	854.03	855.69
35%	1,309	10.77	782.29	793.06
40%	1,323	112.61	659.73	772.34

Next, we use the simulation model to search for the optimal UTL in the range of $1,100 and $1,400 by an increment of $10. The results for each value of marginal tax rate (τ) are reported in Table 6.

TABLE 6
OPTIMAL RESULTS PROVIDED BY SIMULATION FOR THE EXTENDED VERSION

τ	Simulation Optimal UTL	Average Extra Payment (After-tax) $/year	Average Deposit (After-tax) $/year	Expected Total Expense (After-tax) $/year
15%	1,100	109.49	944.35	1,053.83
20%	1,120	92.94	904.96	997.90
25%	1,130	85.10	855.98	941.07
30%	1,150	70.40	813.05	883.45
35%	1,160	63.59	761.54	825.13
40%	1,180	51.08	715.08	766.16

The comparative results are reported in Table 7. It is observed that the difference in optimal UTLs obtained by heuristic and simulation methods is equal to or less than 3.11%, and the performance difference is equal to or less than 0.08%. While the heuristic for the basic version shows superior performance, the heuristic for the extended version is also highly effective, providing results very similar to those of simulation optimization.

TABLE 7
SUMMARY OF COMPARATIVE RESULTS FOR THE EXTENDED VERSION

	Optimal UTL			Total expenses (After-tax)		
τ	**Heuristic**	**Simulation**	**Difference in percentage**	**Heuristic**	**Simulation**	**Difference in Percentage**
15%	1,240	1,280	3.11%	1,034.60	1,033.77	0.08%
20%	1,261	1,300	3.01%	974.15	973.56	0.06%
25%	1,279	1,300	1.65%	913.60	913.25	0.04%
30%	1,294	1,310	1.19%	853.05	852.85	0.02%
35%	1,309	1,320	0.82%	792.45	792.37	0.01%
40%	1,323	1,330	0.51%	731.85	731.84	0.00%

CONCLUSION AND DISCUSSION

In response to the challenges of determining the optimal contribution amount for FSAs, this study transformed this personal finance problem into an inventory management problem for perishable products under a lost-sale and periodic review policy. This transformation allows us to leverage established optimization theories from inventory management literature to develop effective heuristics for addressing the FSA contribution problem. Using the proposed heuristics, we determined the optimal UTLs and compared them with the results achieved through simulation optimization. The comparative results show the performance of the heuristics is very close to that provided by the simulation optimization.

The proposed heuristics are very practical for individual employees and policymakers in the decision-making process without requiring extensive training or skills in simulation and optimizations. While the proposed heuristics were developed based on healthcare FSAs, it can also apply to the dependent care FSA, which can be claimed for reimbursement for child-related expenses, such as daycare, preschool, a nanny, or an after-school program. The situation of a dependent care FSA is relatively simpler than that of a healthcare FSA because the demand for a dependent care FSA is more stable and predictable.

This research also opens avenues for potential future studies. First, while the decision period for FSA contributions typically occurs at the end of the year, it can range from November to December (FSAStore, 2024). This study assumes December 31 as the deadline, meaning no lead time is involved. Future research could improve the model’s accuracy by considering lead time. Second, beyond the extended version, some employers offer an option allowing employees to carry over a certain amount of their FSA funds into the following year. Investigating this option and comparing it with the grace-period policy offered in the extended version could provide employees further insights and guidance. Third, further research could incorporate behavioral factors into the decision-making. The impacts of saving one dollar and losing one dollar could differ significantly depending on an individual’s risk aversion preference. Understanding these behavioral aspects could enhance the model’s applicability and accuracy.

Overall, this exploratory interdisciplinary study applies inventory management optimization theories to solve a personal finance problem. It offers practical applications for employees and policymakers, highlighting potential research directions for future scholars.

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