MGT 40750 – Quantitative Decision Modeling
Spring 2017

Linear Programming

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Optimization

- **Main Idea**: Finding the best way to allocate limited resources
- Applications
  - Supply chain optimization: used by UPS, FedEx, GE, Schneider, etc.
  - Portfolio optimization: used by numerous Wall Street firms.
  - Airline scheduling: used by all major airlines.
  - Product mix: used by major oil companies, beverage manufacturers, etc.
  - Sales of TV ads: used by all broadcast TV networks such as ABC, CBS, NBC, FOX, CW, etc.
  - Sports scheduling: used by all major professional and college sports leagues.
  - Health care: kidney swaps.
- Recent survey: 85% of Fortune 500 firms use optimization.

IBM ILOG Optimization and Analytical Decision Support Solutions

Make smarter decisions, faster with optimization technology

Why IBM?

IBM ILOG Optimization & Analytical Decision Support Solutions provide proven and rapid ROI by helping businesses create the best possible plans, explore alternatives, understand trade-offs, and respond to changes in business environment. They leverage the investments you are making in enterprise information technology and business process automation.

The gold standard in optimization software, technology and solutions, IBM ILOG Optimization is used by over 50% of the world's largest companies, 1000's of Universities, and 1000's of application providers. The leader in optimization and performance, IBM ILOG Optimization solutions tackle the world's toughest problems allowing firms to gain a unique competitive advantage for a very wide range of optimization applications.

IBM ILOG Supply Chain Optimization provides easy-to-use, optimization-based decision support solutions to solve complex supply chain and production problems. These off-the-shelf applications are used by over 50% of the world's largest supply chains and over 50% of AMR's top 50 global supply chains.

Success Stories: By industry

Automotive:

- Johnson Controls reduces supply chain spend with IBM ILOG LogicNet Plus
  Johnson Controls Power Solutions delivers batteries to its more than 10,000 customer locations on a regular basis. This world-class delivery operates within a closed-loop battery supply chain.

Consumer Products:

- Südzucker Finds Sweet Spot in Supply Chain Optimization with IBM Solutions
  Südzucker is Europe's leading supplier of sugar products and has an annual revenue of approximately €7 billion. The sugar segment of Südzucker operates 29 sugar factories and three refineries in 11 European countries and produces 5.4 million tons of sugar.
- Armstrong World Industries Improves Decision Making in the Supply Chain with IBM ILOG LogicNet Plus XE
  Armstrong needed a repeatable process to ensure that the supply chain decisions were correct from the start.

Energy & Utilities:

- XM keeps the power on with IBM ILOG optimization software
  The Colombian electricity sector needs to match the supply to the demands of the distribution companies for the following day. XM uses IBM WebSphere ILOG optimization software to determine the most efficient, low-cost and reliable operation of the Colombian power system.

Fabrication & Assembly:

- Selco S.p.A
  An arc welding systems and power source manufacturer in Italy reduces its inventory by 15 percent, cuts the amount of lost orders by 70 percent and automates production when it engages IBM Business Partner MBM to implement IBM ILOG CPLEX Optimization Studio software.

Financial Markets:

- Fiserv ... Helping banks lower the cost of managing cash inventories
  Fiserv uses IBM ILOG CPLEX Optimization Studio to optimize the costs of replenishing ATMs and balancing the costs of vault inventories.
- INDEVAL saves Mexican banks 240 million USD in 18 months
  Mexican financial institutions were challenged by reserve requirements and high borrowing costs. The solution was a new securities settlement system using operations research to maximize the value of pending trades and settle securities transactions in near real time.

Travel & Transportation:

- Odyssey Logistics & Technology Corporation increases agility
  Odyssey Transportation & Logistics Corporation uses IBM WebSphere software to optimize its processes to better meet its customers' needs. OL&T creates its next-generation logistics management platform using IBM BPM, IBM WebSphere ILOG JRules, IBM WebSphere Partner Gateway and IBM ILOG CPLEX Optimization Studio software.

http://www.cbsnews.com/2102-505125_162-51188137.html

February 13, 2008

How Operations Research Drives Success at P&G

By **Andrew Hines**

You can't just call it a company anymore — it's more of an economy unto itself. With $76 billion in annual sales, 138,000 employees, and operations in more than 80 countries, Procter & Gamble, the world's biggest consumer goods company, has grown to such epic proportions that economists consider it a bellwether of consumer spending and confidence. Among the more than 300 brands it sells globally, from Gillette and Crest to Scope and Swiffer, 22 generate more than $1 billion in annual revenue. Another 18 pull in at least $500 million.

Yet there's an entirely different element of P&G's success that doesn't show up on the balance sheet, and which figures into almost every key decision driving sales and profits — from choosing the right brand names to slap on new products to precise juggling of global inventories. The secret ingredient? Data — some 900 terabytes of total capacity, 50 TB more than Google searches every day — that P&G uses to measure and optimize almost everything it does.

Three decades ago, P&G's cadre of data analysts was programming simplistic queries into mainframe computers to determine, for instance, the best time of day to deploy television advertising. It mostly trusted executives' instincts when deciding when to launch a new product or how much inventory to put on store shelves. These days, thanks to exponentially more powerful computers, data retrieval and storage, and new generations of software, it's a central army of "quants" at P&G who are arguably as important to its overall success as those storied P&G brand managers.

The company has raced to the forefront of data innovation in recent years, and has turned analytics — or operations research (OR), as it's more widely known — into a competitive edge that few others fully understand. As Brenda Dietrich, an IBM fellow at IBM's Watson Research Center, explains, "There's a gap between the math professionals and the nonmath executives in many companies. The companies who have people who can walk into a business meeting and tell executives how to use OR tools are the ones who've got the edge. Deployment is no longer done just by the math people; analytics has become much more usable by a broader set of people within an organization."

At P&G, it's top quants like Glenn Wegryn, associate director of product supply analytics, who have quietly led the data revolution. Wegryn's team of 20 analytics pros combines enterprise-scale simulation and risk assessment software with in-house tool sets to help streamline supply chains, launch new brands, generate internal workflow models and tackle a host of other operational and organizational problems. According to Wegryn, P&G doesn't make any significant analyses on supply-chain structure without input from his team, since data crunching that can improve the slightest of margins in a company of P&G's size can generate huge dividends. "The consumer products industry is cost driven, and a lot of it is commodity type in nature," Wegryn explains. "So very efficient and effective supply chains are critical for success and the ultimate profitability of the company. OR techniques, when utilized effectively, save costs, reduce cash investments and inventory, and can even improve top-line growth."

P&G, GE, Merrill Lynch, UPS — the list of Fortune 500 companies getting into the OR game is expanding, says Mark Doherty, executive director of the Hanover, MD-based Institute for Operations Research and Management Sciences (INFORMS), an OR think tank. "In the private sector, OR is the secret weapon that helps companies tackle complex problems in manufacturing, supply chain management, health care, and transportation," he says. "In government, OR helps the military create and evaluate strategies. It also helps the Department of Homeland Security develop models of terrorist threats. That's why OR is increasingly referred to as the 'science of better.'"

Rise of the Quants

The current analytics strategy at P&G took root in 1992, when Wegryn and a team of analytic professionals took on a daunting challenge: The company had too many manufacturing plants scattered around the country, and needed to eliminate redundant capacity, figure out optimal inventory holding policies, and develop other techniques that could optimize a supply chain that spanned continents. The data formulas Wegryn began churning through weighed myriad factors, including the impact of NAFTA on operations, trucking deregulation, and redundant capacity issues. The team, which included 30 managers and upwards of 1,000 employees around the country, spent a little less than a year devising tools that generated various consolidation scenarios. The team's recommendations ultimately allowed P&G to shut down multiple plants and have since generated more than $1 billion in cost savings.

Small wonder, then, why mathematicians are in on business decision making in many companies, not just P&G. Entire companies today — Google, for one — are being built almost entirely on mathematical modeling. "We all know the slogan 'Intel Inside,'" says Vijay Mehrotra, professor of decision science at San Francisco State University. "But we don't automatically think, 'Is there OR inside?' And yet there is, in a staggering number of things. When you book a car with Hertz, and instead of saying, 'It's unavailable,' they say, 'It's available for $59, not $39' — *that's* OR inside. Today it's embedded in the way we do business."

P&G's Killer Apps in OR

Streamlining manufacturing plants was just the start. Here are a handful of other killer apps in OR that Wegryn has since developed and refined at P&G:

New product branding: Several years ago, Wegryn used decision analysis techniques to help managers decide to use Crest as the brand name on Crest White Strips. Granted, that might seem like a no-brainer, but it was a complex decision because the teeth-whitening category was new — a situation in which a new, stand-alone brand name would perhaps make sense. P&G turned to their analytics team to sort matters out, and, as a result, Crest was chosen as the brand. Wegryn says the process involved "getting clear on the question, evaluating options, understanding the uncertainties, and analyzing the best decision that you have available. In the end it was decided to use the brand equity Crest had."

Sourcing materials: Every product at P&G requires myriad materials, obtained from hundreds of different sources worldwide. Using OR techniques, Wegryn's team analyzes which source is optimal for every product. "A lot of times, there's service and quality considerations," Wegryn says. "We also measure whether a manufacturer really has the capability to deliver the materials at the quoted price." For instance, retail clients of P&G spend $140 million per year on in-store displays for P&G brands in the United States alone, often buying the display from one vendor. By using OR to determine the best source via a Web interface, P&G now pockets nearly $67 million annually in cost savings and has slashed the order-and-delivery cycle for store displays from 20 weeks to just eight.

International trade and finance: P&G has ground operations in 86 countries, posing huge logistical and financial challenges. With products constantly crossing national borders, P&G is exposed to considerable exchange rate risk, where margins can be squeezed by the tiniest movements in currency. Wegryn's group taps into software that helps predict optimal exchange rates and allows plant managers to shift production accordingly. "Let's say there's one plant in the US and one in Europe," Wegryn explains. "Based on the exchange rate, we will adjust where we're manufacturing and sourcing product from. It's not a massive adjustment, but just a slight adjustment to minimize exchange exposure and maximize the profit, ultimately, for the business."

Inventory management: At giant-sized P&G, inventory management is crucial to overall efficiency. "How much inventory do I need, and where do I need to have it," explains Wegryn, "are really simple questions that are really hard to answer." Using OR, the company now fine-tunes inventory dynamics. For example, conventional wisdom once held that adding a new warehouse to a supply chain would always add inventory into the system as well, ratcheting up costs. But using analytic methods, Wegryn's team poked holes in this assumption, showing that new inventory need not be added. Their work was able not only to economically justify a new warehouse, but by using better methods, they were also able to track and put exactly the right

amount of inventory in the system, reducing overhead costs. "The huge deal about this application of OR is that we've been doing it for 15 years," he says. "It's used in every area of P&G."

Organizational design: Wegryn hasn't aimed OR's powerful lens on just strategic problems, but internal management challenges as well. Over the past few years, Wegryn has developed simulation models that help execs in each of the company's five major business organizations keep tabs on their organizational structure and inflow of talent. Taking into account variables such as hiring rates, attrition, retirement, movement between jobs, promotion rates, and so on, the quants created a "flow model" that shows managers what the likely flow of people moving in, out, and within an organization will be over the course of months or years, helping them to determine where they should be hiring most and when.

Toward "OR Inside"

One of the first myths about OR is that it applies only to operational issues. By every measure at P&G, however, OR is a cross-functional discipline applied to anything from executive compensation to inventory management. Wegryn says his analytics group looks at every business problem and asks: "Is it a strategic problem, is it a structural problem, or is it an operational problem? We are called into various problems throughout the entire spectrum."

P&G's OR tools fall into four broad categories, according to Wegryn: structured analytical modeling using a spreadsheet-type technology; decision-making analysis methods; mathematical modeling in the form of optimization; and simulation technology.

Within those categories, Wegryn has subsets. One he calls "OR inside" — packaged tool sets from an enterprise vendor. P&G uses outside vendors for optimization software, simulation software, object-based simulation modeling tools, and risk assessment software for decision analysis. Wegryn believes that embedded analytics in commercially available packages are a baseline for any big company to stay in the game. "Our competitors utilize OR tools that are embedded in solutions, as we do, and that is simply to stay competitive."

But "canned" OR doesn't come prepackaged with what Wegryn calls "company intelligence" — data that's specific to the nature of a particular company's problems and challenges. That's where "applied OR" comes in. Applied OR is project-specific, utilizing customized tools developed by the company's analytic team that target particular problems. "We have done analyses throughout the world on very specific questions," Wegryn says, "like what is the proper balance between capacity at a particular plant and the inventory it should be holding, to help responsiveness to our customers."

Whatever the application, his team collaborates closely with members of P&G's IT team — the company's Global Business Services unit has several hundred employees operating in analytics alone — in order to get the answers to many of P&G's problems. Says Wegryn: "We develop the algorithms and mathematics inside, but as far as database and systems architecture and deployment and support, we defer to our IT colleagues."

In the 23 years since she joined Big Blue, IBM's Dietrich has seen OR evolve "from data gathering that took months and months" to OR available on the desktop. "We can now deliver to executives software that, with a click of a button, can run models and present results. But it takes work to get OR embedded in daily business, and it takes people who can present OR to executives in a concrete way. The bottleneck in OR today is people — the industry is short on people who can deploy OR and frame it in a business context."

And that is what gives Wegryn his unique status at P&G: He can talk business, and his business counterparts listen. "Rarely are we walking in front of a senior manager without any in-business support for the work we've been doing," he says. "We go off, we analyze options, we come up with a recommended plan, and then we present that to management. Do they throw us out of the office for screwball ideas? The short answer is no. We've developed a reputation of having an unbiased view of how the business operates, and we've earned their trust."

Additional reporting by Jake Swearingen.

Example: Advertising

- Chery Automobile
  - One of the largest Chinese automobile manufacturers.
  - The top Chinese vehicle exporter in recent years.
- Chery QQ
  - QQ has been Chery's most sold model
  - "a legend in the Chinese automobile history ... a mini model with the highest cumulative sales in China"

Chery QQ

- Guinness World Records
  - Set a world record of "four-vehicle crossing" in 2010: maximum vertical distance of 6 meters
    2 Chery QQ and 2 motorcycles leap from 4 directions. When the 4 vehicles form a vertical line, the distance of the highest motorcycle and the lowest QQ cannot exceed 6 meters.
  - Broke the world record of "narrowest drifting" in 2009: 32cm

ONLY
$ 4,400 !!!

Example: Advertising

- Chery Automobile advertises its QQ model in a variety of 30-second television ads, and these ads can be placed in a variety of television shows. The ads in different shows vary by cost – some 30-second slots are much more expensive than others – and by the types of viewers they are likely to reach.
- The company has segmented the potential viewers into six mutually exclusive categories:
  - males age 18 to 35
  - males age 36 to 55
  - males over 55
  - females age 18 to 35
  - females age 36 to 55
  - females over 55

Example: Advertising

- A rating service can supply data on numbers of viewers in each of these categories who will watch a 30-second ad on any particular television show. Each such viewer is called an *exposure*.
- Chery has determined the required number of exposures it wants to obtain for each group.
- Detailed data on costs per ad, numbers of exposures per ad, and minimal required exposures can be found in Excel file "Chery Advertising.xlsx", where numbers of exposures are expressed in millions, and costs are in thousands of dollars.
- Chery wants to know how many ads to place on each of the several television shows to obtain these required exposures at a minimum cost.

Example: Advertising

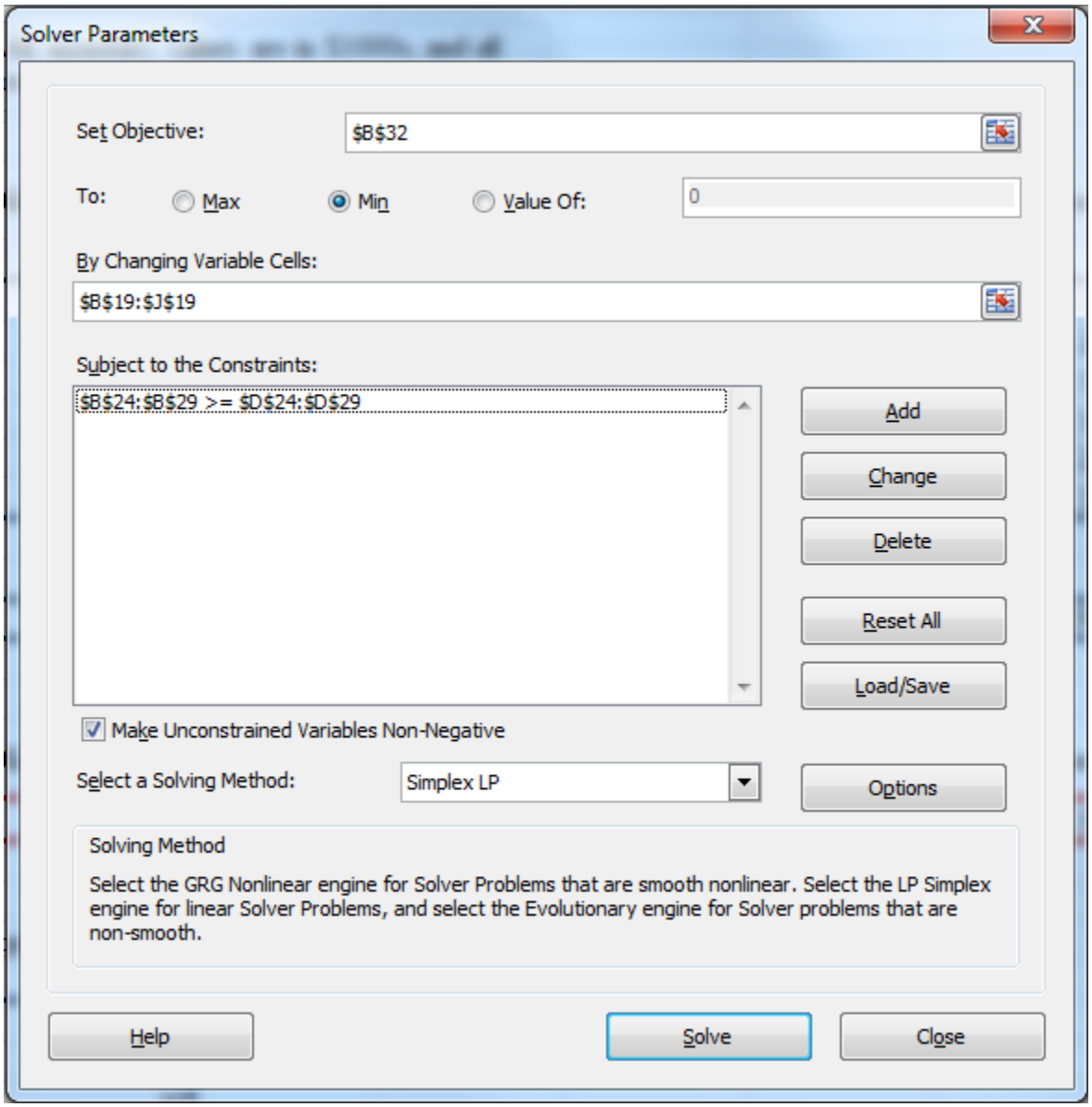
One way to set up the Chery advertising model in Excel for Solver:

	A	B	C	D	E	F	G	H	I	J
1	**Advertising model**									
2				**Note:** All monetary values are in $1000s, and all exposures to ads are in millions of exposures.						
3	**Inputs**									
4	Exposures to various groups per ad									
5		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
6	channel	CBS	FOX	CW	FOX	CBS	ABC	CBS	NBC	CBS
7	Men 18-35	4.5	4.0	0.2	2.5	2.0	2.0	3.5	1.0	4.0
8	Men 36-55	2.0	3.0	0.1	1.5	1.5	1.5	3.5	2.5	3.0
9	Men >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
10	Women 18-35	4.5	1.5	1.5	3.5	2.0	2.0	2.0	1.0	3.0
11	Women 36-55	2.0	1.5	0.2	1.5	1.5	1.5	3.0	2.5	3.0
12	Women >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
13	**Viewers (millions)**	14	11	2	10	9	9	16	9	15
14										
15	**Cost per 30 sec($)**	192	108	59	127	145	130	167	191	201
16										
17	**Advertising plan**									
18		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
19	Number ads purchased									
20										
21	**Constraints on numbers of exposures**									
22		Actual exposures		Required exposures						
23				by Chery						
24	Men 18-35	=sumproduct(B7:J7,B$19:J$19)		80						
25	Men 36-55			56						
26	Men >55		≥	30						
27	Women 18-35			120						
28	Women 36-55			56						
29	Women >55			30						
30										
31	**Objective to minimize**									
32	Total cost	=sumproduct(B15:J15,B19:J19)								

Using Solver:

- From Excel menu (typically under Data), open Solver.
- Enter objective function and variable cells.
- To enter constraints, click "Add," then enter left and right sides of constraints and type of relationship between them.
- If all variables are greater than or equal to zero, check "Make Unconstrained Variables Non-Negative."
- Select a solving method. If model is linear, select Simplex LP.
- Click "Solve," then "Keep Solver Solution."

Inputting the Advertising model into Solver:



Solution to the Advertising model:

	A	B	C	D	E	F	G	H	I	J
1	**Advertising model**									
2				**Note:** All monetary values are in $1000s, and all exposures to ads are in millions of exposures.						
3	**Inputs**									
4	Exposures to various groups per ad									
5		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
6	channel	CBS	FOX	CW	FOX	CBS	ABC	CBS	NBC	CBS
7	Men 18-35	4.5	4.0	0.2	2.5	2.0	2.0	3.5	1.0	4.0
8	Men 36-55	2.0	3.0	0.1	1.5	1.5	1.5	3.5	2.5	3.0
9	Men >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
10	Women 18-35	4.5	1.5	1.5	3.5	2.0	2.0	2.0	1.0	3.0
11	Women 36-55	2.0	1.5	0.2	1.5	1.5	1.5	3.0	2.5	3.0
12	Women >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
13	**Viewers (millions)**	14	11	2	10	9	9	16	9	15
14										
15	**Cost per 30 sec($)**	192	108	59	127	145	130	167	191	201
16										
17	**Advertising plan**									
18		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
19	Number ads purchased	0.0	0.0	0.0	30.0	0.0	0.0	7.5	0.0	0.0
20										
21	**Constraints on numbers of exposures**									
22		Actual exposures		Required exposures						
23				by Chery						
24	Men 18-35	101.3	>=	80						
25	Men 36-55	71.3	>=	56						
26	Men >55	30.0	>=	30						
27	Women 18-35	120.0	>=	120						
28	Women 36-55	67.5	>=	56						
29	Women >55	30.0	>=	30						
30										
31	**Objective to minimize**									
32	Total cost	5,062.5								

Integer Solution to the Advertising model:

Add a constraint in Solver: B19:J19=integer

	A	B	C	D	E	F	G	H	I	J
1	**Advertising model**									
2				**Note:** All monetary values are in $1000s, and all exposures to ads are in millions of exposures.						
3	**Inputs**									
4	Exposures to various groups per ad									
5		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
6	channel	CBS	FOX	CW	FOX	CBS	ABC	CBS	NBC	CBS
7	Men 18-35	4.5	4.0	0.2	2.5	2.0	2.0	3.5	1.0	4.0
8	Men 36-55	2.0	3.0	0.1	1.5	1.5	1.5	3.5	2.5	3.0
9	Men >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
10	Women 18-35	4.5	1.5	1.5	3.5	2.0	2.0	2.0	1.0	3.0
11	Women 36-55	2.0	1.5	0.2	1.5	1.5	1.5	3.0	2.5	3.0
12	Women >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
13	**Viewers (millions)**	14	11	2	10	9	9	16	9	15
14										
15	**Cost per 30 sec($)**	192	108	59	127	145	130	167	191	201
16										
17	**Advertising plan**									
18		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
19	Number ads purchased	0.0	0.0	0.0	30.0	0.0	1.0	7.0	0.0	0.0
20										
21	**Constraints on numbers of exposures**									
22		Actual exposures		Required exposures						
23				by Chery						
24	Men 18-35	101.5	>=	80						
25	Men 36-55	71.0	>=	56						
26	Men >55	30.0	>=	30						
27	Women 18-35	121.0	>=	120						
28	Women 36-55	67.5	>=	56						
29	Women >55	30.0	>=	30						
30										
31	**Objective to minimize**									
32	Total cost	5,109								

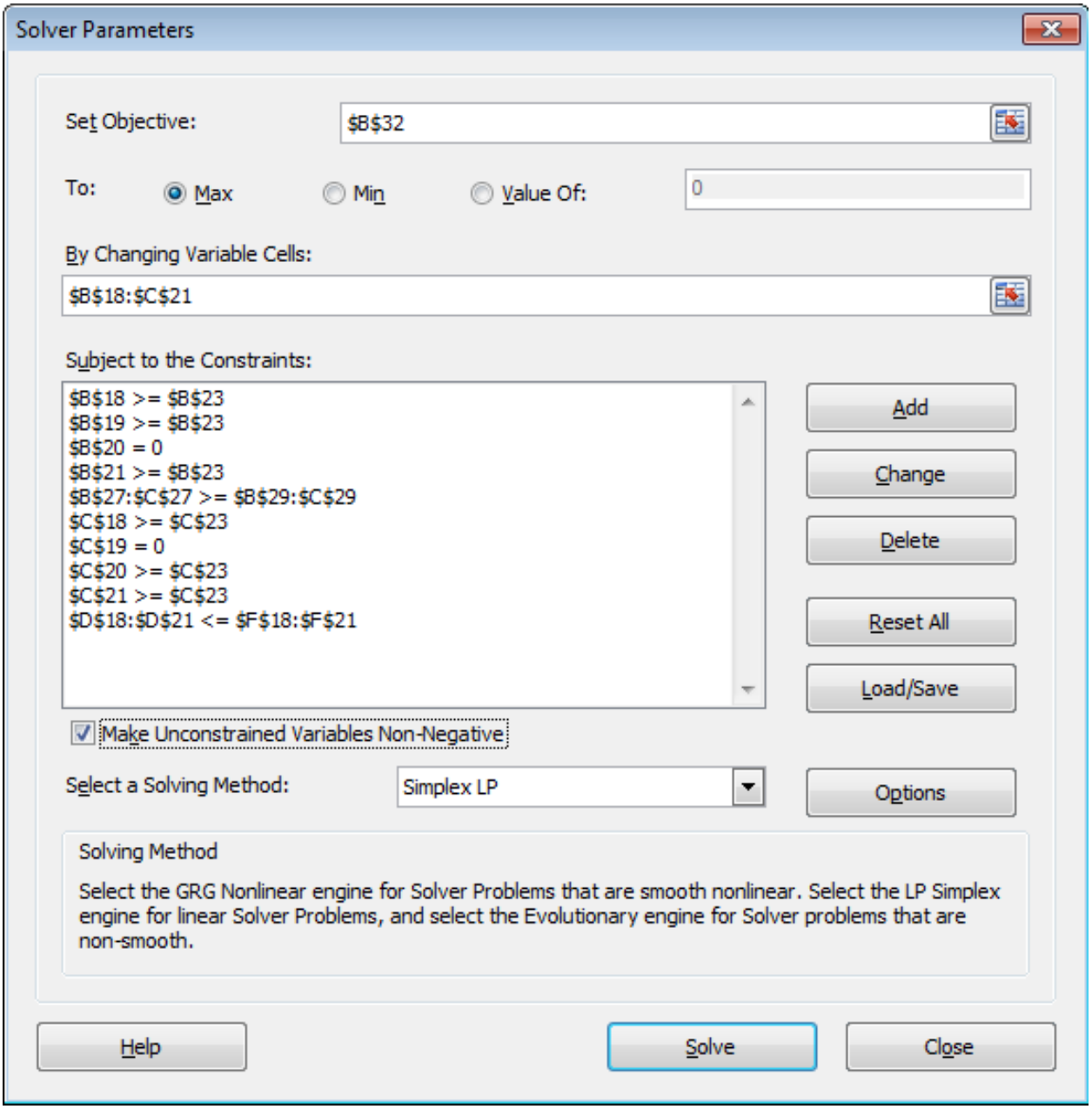
Example: Mixing Drinks at Club Fever

We are asked by Club Fever to come up with the optimal plan to mix drinks for a Thursday night. Excel file "Mixing Drinks.xlsx"

Set up the Mixing Drinks model in Excel for Solver:

	A	B	C	D	E	F
1	**Mixing Drinks**					
2						**Notes: Recipe (1 cup = 6 ounces)**
3	**Monetary inputs**	Sex on the Beach	Cosmopolitan			**1 Cup of Sex on the Beach**
4	Selling price/cup	$5.00	$7.00			>= 1 ounce of Vodka
5						>= 1 ounce of Peach Schnapps
6	**Alcohol percentage of ingredients**					>= 1 ounce of Fruit Juice
7	Vodka	0.40				**1 Cup of Cosmopolitan**
8	Peach Schnapps	0.21				>= 1 ounce of Vodka
9	Triple Sec	0.30				>= 1 ounce of Triple Sec
10	Fruit Juice	0.00				>= 1 ounce of Fruit Juice
11						
12	**Required alcohol percentage**					
13		Sex on the Beach	Cosmopolitan			
14		0.12	0.30			
15						
16	**Blending plan**					
17		Sex on the Beach	Cosmopolitan	Ounces used		Available ingredients (ounces)
18	Vodka			=sum(B18:C18)		1200
19	Peach Schnapps			↓	≤	600
20	Triple Sec					500
21	Fruit Juice					3000
22	Ounces produced	=sum(B18:B21) →				
23	Cups sold	=B22/6 →				
24						
25	**Constraints on alcohol percentage**					
26		Sex on the Beach	Cosmopolitan			
27	Alcohol obtained (ounces)	=sumproduct($B7:$B10,B18:B21) →				
28		≥				
29	Alcohol required (ounces)	=B14*B22 →				
30						
31	**Objective to maximize**					
32	Revenue	=sumproduct(B4:C4,B23:C23)				

Entering the Mixing Drinks model into Solver:



Solution to the Mixing Drinks model:

	A	B	C	D	E	F
1	**Mixing Drinks**					
2						**Notes: Recipe (1 cup = 6 ounces)**
3	**Monetary inputs**	Sex on the Beach	Cosmopolitan			**1 Cup of Sex on the Beach**
4	Selling price/cup	$5.00	$7.00			>= 1 ounce of Vodka
5						>= 1 ounce of Peach Schnapps
6	**Alcohol percentage of ingredients**					>= 1 ounce of Fruit Juice
7	Vodka	0.40				**1 Cup of Cosmopolitan**
8	Peach Schnapps	0.21				>= 1 ounce of Vodka
9	Triple Sec	0.30				>= 1 ounce of Triple Sec
10	Fruit Juice	0.00				>= 1 ounce of Fruit Juice
11						
12	**Required alcohol percentage**					
13		Sex on the Beach	Cosmopolitan			
14		0.12	0.30			
15						
16	**Blending plan**					
17		Sex on the Beach	Cosmopolitan	Ounces used		Available ingredients (ounces)
18	Vodka	765	435	1200	<=	1200
19	Peach Schnapps	600	0	600	<=	600
20	Triple Sec	0	290	290	<=	500
21	Fruit Juice	2235	145	2380	<=	3000
22	Ounces produced	3600	870			
23	Cups sold	600	145			
24						
25	**Constraints on alcohol percentage**					
26		Sex on the Beach	Cosmopolitan			
27	Alcohol obtained (ounces)	432	261			
28		>=	>=			
29	Alcohol required (ounces)	432	261			
30						
31	**Objective to maximize**					
32	Revenue	4,015				

Questions:

1. With the above optimal mixing, Club Fever will obtain a revenue of $4,015.

2. If Club Fever need to produce at least 200 cups of Cosmopolitan, how should we modify the model? How would the revenue change as a result of this modification?

Add a constraint: C23 $\geqslant$ 200. Revenue would decrease to $3,942.

3. Based on the original model, how much is Club Fever willing to pay for 2 additional handles (60 ounces each) of Peach Schnapps?

Increase the available Peach Schnapps to 720 (= 600 + 2 * 60).
Revenue would increase to $4,258.
Maximum willingness to pay = $4,258 – $4,015 = $243.

Example: Foreign currency trading

Suppose you have 1 million US dollars to invest in currency markets. The cross-currency rates are showed in the Excel file "Currency Trading.xlsx". Develop an LP (linear programming) model to determine whether there are any arbitrage opportunities with the given currency rates.

An example to help understand *cross currency rates*:

Cross currency rates (from along side, to along top)					
	US Dollar	**British Pound**	**Euro**	**Japanese Yen**	**Brazilian Real**
US Dollar	1	0.60639	0.88363	118.27	2.9092
British Pound	1.6491	1	1.45751	195.07	4.79931
Euro	1.1317	0.6861	1	133.77	3.29496
Japanese Yen	0.008455	0.005126	0.007476	1	0.02462
Brazilian Real	0.34374	0.20836	0.30349	40.62285	1

- 0.20836 in the cross currency rate table means that 1 Brazilian real can purchase 0.20836 pound.
- If you purchase 1 million Brazilian real with British pounds, then converting it back to pounds:
  Pounds required to purchase: 1,000,000/4.79931 = 208363
  Pounds obtained by selling back: 1,000,000*0.20836 = 208360
  Difference (In – Out): 208360-208363 = -3

An example to help understand *conversion amounts*:

- Suppose you spend 100 US dollars to purchase British Pound and 100 US dollars to purchase Japanese Yen. Fill out the following conversion table.

Conversion amounts (from along side, to along top)						
	US Dollar	**British Pound**	**Euro**	**Japanese Yen**	**Brazilian Real**	Total out
US Dollar	0	100	0	100	0	200
British Pound	0	0	0	0	0	0
Euro	0	0	0	0	0	0
Japanese Yen	0	0	0	0	0	0
Brazilian Real	0	0	0	0	0	0
Total in	0	60,639	0	11,827	0	
Total out	200	0	0	0	0	
Final net in	-200	60,639	0	11,827	0	

Excel Model Setup:

	A	B	C	D	E	F	G
1	**Foreign currency trading**						
2							
3	Cross currency rates (from along side, to along top)						
4		**US Dollar**	**British Pound**	**Euro**	**Japanese Yen**	**Brazilian Real**	
5	**US Dollar**	1	0.60639	0.88363	118.27	2.9092	
6	**British Pound**	1.6491	1	1.45751	195.07	4.79931	
7	**Euro**	1.1317	0.6861	1	133.77	3.29496	
8	**Japanese Yen**	0.008455	0.005126	0.007476	1	0.02462	
9	**Brazilian Real**	0.34374	0.20836	0.30349	40.62285	1	
10							
11	**Opportunity for arbitrage?**						
12	Conversion amounts (from along side, to along top)						
13		**US Dollar**	**British Pound**	**Euro**	**Japanese Yen**	**Brazilian Real**	Total out
14	**US Dollar**						=sum(B14:F14)
15	**British Pound**						↓
16	**Euro**						
17	**Japanese Yen**						
18	**Brazilian Real**						
19	Total in	=sumproduct(B5:B9,B14:B18) →					
20	Total out	=transpose(G14:G18)		ctrl+shift+enter			
21	Final net in	=B19-B20 →					
22				≥			
23	Nonnegative	0	0	0	0	0	
24							
25	Final net $ in	=B21	≤ or =	$ 1.00			

Specify Solver:

Set Objective: B25

To: X Max ○ Min ○ Value of: _____

By Changing Variable Cells: B14:F18

Subject to the Constraints:

B21:F21 ≥ B23:F23
B25 ≤ D25 (= works too)

X Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP

Solution to the Foreign Currency Trading model:

	A	B	C	D	E	F	G
1	**Foreign currency trading**						
2							
3	Cross currency rates (from along side, to along top)						
4		**US Dollar**	**British Pound**	**Euro**	**Japanese Yen**	**Brazilian Real**	
5	**US Dollar**	1	0.60639	0.88363	118.27	2.9092	
6	**British Pound**	1.6491	1	1.45751	195.07	4.79931	
7	**Euro**	1.1317	0.6861	1	133.77	3.29496	
8	**Japanese Yen**	0.008455	0.005126	0.007476	1	0.02462	
9	**Brazilian Real**	0.34374	0.20836	0.30349	40.62285	1	
10							
11	**Opportunity for arbitrage?**						
12	Conversion amounts (from along side, to along top)						
13		**US Dollar**	**British Pound**	**Euro**	**Japanese Yen**	**Brazilian Real**	Total out
14	**US Dollar**	0.00	978.10	0.00	0.00	0.00	978.10
15	**British Pound**	0.00	0.00	593.11	0.00	0.00	593.11
16	**Euro**	0.00	0.00	0.00	0.00	864.46	864.46
17	**Japanese Yen**	0.00	0.00	0.00	0.00	0.00	0.00
18	**Brazilian Real**	2848.36	0.00	0.00	0.00	0.00	2848.36
19	Total in	979.10	593.11	864.46	0.00	2848.36	
20	Total out	978.10	593.11	864.46	0.00	2848.36	
21	Final net in	1.00	0.00	0.00	0.00	0.00	
22		>=	>=	>=	>=	>=	
23	Nonnegative	0	0	0	0	0	
24							
25	Final net $ in	1.00	<=	$ 1.00			

Based on the above results, what's your best currency trading strategy?

US Dollar → British Pound → Euro → Brazilian Real → US Dollar

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Miles for Nothing: How the Government Helped Frequent Fliers Make a Mint

Free Shipping of Coins, Put on Credit Cards, Funds Trip to Tahiti; 'Mr. Pickles' Cleans Up

By SCOTT MCCARTNEY

Enthusiasts of frequent-flier mileage have all kinds of crazy strategies for racking up credits, but few have been as quick and easy as turning coins into miles.

At least several hundred mile-junkies discovered that a free shipping offer on presidential and Native American $1 coins, sold at face value by the U.S. Mint, amounted to printing free frequent-flier miles. Mileage lovers ordered more than $1 million in coins until the Mint started identifying them and cutting them off.

Coin buyers charged the purchases, sold in boxes of 250 coins, to a credit card that offers frequent-flier mile awards, then took the shipments straight to the bank. They then used the coins they deposited to pay their credit-card bills. Their only cost: the car trip to make the deposit.

Richard Baum, a software-company consultant who lives in New Jersey, ordered 15,000 coins. "I never unrolled them," he says. "The UPS guy put them directly in my trunk."

Patricia Hansen, a San Diego retiree who loves to travel, ordered $10,000 in coins from the Mint. "My husband took them to the bank," Ms. Hansen says, and she earned 10,000 miles toward free or upgraded travel.

That's small change compared with what some mile collectors did. The coin program was a popular play on FlyerTalk.com, an online community where frequent travelers and mileage mavens share travel tips and profitable mileage plays. One FlyerTalker, identified by his online moniker, Mr. Pickles, claims to have bought $800,000 in coins. He posted pictures of the loot on FlyerTalk.

He says his largest single deposit was $70,000 in $1 coins. He used several banks and numerous credit cards. He earned enough miles to put him over two million total at AMR Corp.'s American Airlines, giving him lifetime platinum-elite status -- early availability of upgrades for life and other perks on American and its partners around the world. He also pumped miles into his account at UAL Corp.'s United Airlines and points into his Starwood Preferred Guest program account.

A spokesman for the Mint says it has no record of anyone purchasing that many coins, but orders could have been shipped to different names and addresses.

Another FlyerTalk member used the coin program to help earn a free two-week trip to Tahiti that he took with his wife at the end of October. He worked hotel, airline and credit-card programs carefully to pull together the rewards he wanted.

The allure of frequent-flier miles, which were introduced by American in 1981, was that they offered something for nothing. The miles rewarded loyalty and proved to be an extremely powerful marketing tool.

Now, airlines have turned miles into more than a competitive device; they have become a currency that airlines can sell, usually at less than a penny a mile, to other merchants to generate revenue. More miles are put into circulation by companies -- including credit-card issuers, hotels, mortgage servicers, and florists -- than are given to travelers for flights.

The mile is such a cherished commodity that airlines have even bolstered their balance sheets by preselling billions of miles. Citigroup Inc., which gives away American AAdvantage miles to credit-card customers, agreed to lend American $1 billion in September. The loan is to be repaid between 2012 and 2016 -- not in cash but in miles.

Pushing miles into everyday commerce has created unique opportunities for mileage addicts. For many, chasing miles is a way to vastly improve their travel. Accumulate enough miles to land elite status, and you get early boarding, better seat selection, access to upgrades, premium check-in and security lines, and sometimes use of fancy airport lounges on international trips. It goes far beyond just tallying miles for free tickets.

FlyerTalk

Some fliers have been taking advantage of a free-shipping offer from the U.S. Mint to rack up frequent-flier miles by buying dollar coins.

Landing those free tickets has gotten more expensive in recent years as airlines have pushed the number of miles required for many trips higher and as they have added fees and co-payments to some awards. Consumers are often frustrated as well by difficulty in getting the trips they want on the dates they want since airlines restrict availability of award seats. But the airline mile remains a potent perk that consumers chase around the world.

Even with all the offers that are available, the deal the Mint offers -- free miles without spending any dollars -- is unique. The Mint says the dollar-coin free-shipping offer began in June 2008. About $130 million in coins have been issued to 40,000 buyers, mostly coin collectors, community banks and small businesses such as vending-machine companies and car washes.

The Mint says it costs, on average, about $3 to ship each 250-coin box. So $10,000 in coins would be 40 boxes, or $120 in shipping. As for credit-card costs to the government, a Treasury Department agency handles all government credit-card transactions and negotiates costs. No particular credit-card expense is charged to the Mint, a spokesman says.

In late August and September, officials noticed a sharp uptick in "large repetitive orders" from a group of individuals, Mint spokesman Tom Jurkowsky says. At about the same time, the Mint received reports from banks around the country that coins were being deposited that were still in their U.S. Mint boxes, he says.

Officials found Internet chat rooms where the coins-for-miles scheme was detailed. Letters were sent to customers asking whether their intended use complied with the program's purpose. Customers who didn't respond were blocked from the program, Mr. Jurkowsky says. Fewer than 400 buyers were blocked, he says.

"Is this illegal? No. Is it the right thing to do? No, it's not what the program is intended to do," Mr. Jurkowsky says.

Dollar coins save the country money because they can last 30 years or more and can be recycled, the Mint says. A paper dollar in circulation lasts only about 21 months, says the U.S. Bureau of Engraving and Printing. The free-shipping program is meant to put more coins into day-to-day use.

The Mint has added a warning to its Web site that credit-card companies could consider the purchases cash-equivalent transactions not eligible for miles, and Mint officials plan to contact credit-card issuers "to try to implement a solution," he says.

Mileage fanatics say merchants and hotel programs can be an excellent way to supplement frequent-flier accounts.

Hyatt Hotels Corp. currently offers its Gold Passport program members a free night for every two nights at one of the chain's properties through Jan. 31. The free nights come with no blackout dates but have to be used by March 31. Charles Witt, a facilities planner in Washington, D.C., stopped by a suburban Hyatt Place hotel on his way home from work several times this fall, swiped his credit card to buy a $50 room and went home, never opening the door to the hotel room.

For every $100 he spent, he got a free night at any Hyatt. He booked three free nights at the Grand Hyatt in Tokyo over New Year's -- rooms that would have cost him $600 a night.

"Once you start on this road, it's very hard to get off," says Mr. Witt.

Hyatt says the promotion is meant to engender loyalty, and most customers use it more traditionally, collecting free nights for regular stays. But the company welcomes people so passionate about its hotels that they'll go to elaborate lengths to stay at Hyatt.

"We don't discourage that," says Jeff Zidell, vice president of Hyatt's Gold Passport program. "There are those extremists in whatever business you're in who do what they can to get the most out of it."

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Giving Yourself the Gift of Miles

Rewards Fiends Discover Easy Way to Get Thousands of Frequent-Flier Points

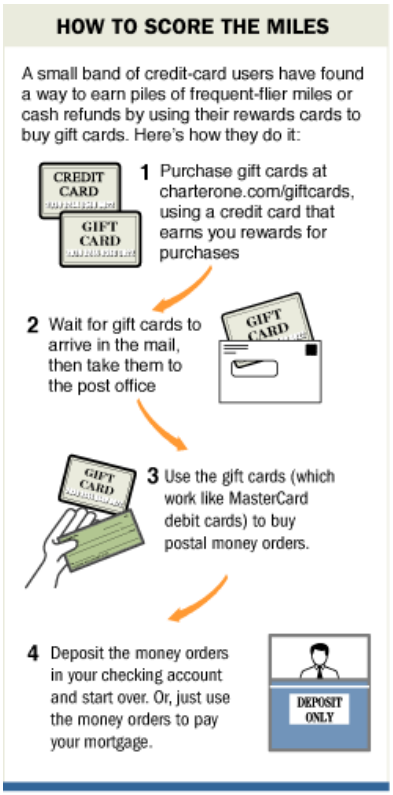
By RON LIEBER | Staff Reporter of THE WALL STREET JOURNAL

There's a hot new gift card out there that comes with an extra present: tons of frequent-flier miles.

In recent months, a small band of people eager to pile up miles or cash refunds from using their credit cards have figured out a clever way to quickly collect rewards. They're using credit cards that earn rewards to buy thousands of dollars of MasterCard gift cards sold by Charter One Financial, a Cleveland-based bank that is trying to make a splash in the gift-card market.

The gift cards, which are preloaded with money, are accepted anywhere regular debit cards work. So people "give" the gift cards to themselves and then find ways to use them.

One way people are using the gift cards is to buy money orders at the post office or Wal-Mart and then deposit them into their bank accounts. They can then use that money to pay their credit-card bill, and start the process over again. There's also the potential to use the money orders to make mortgage payments, which would allow consumers to indirectly earn miles on the biggest bill many of them pay each month. Earning miles for mortgage payments has long been the holy grail for many miles-mad consumers, who yearn for free flights and first-class upgrades.



Charter One's gift cards have proved incredibly popular. The bank sold more than 600,000 gift cards in November and December alone, for a total of about $40 million. Mark Grossi, the company's chief retail banking officer, believes Charter One sold more gift cards than any other bank in that period.

The success of the gift-card program -- both with everyday consumers and with rewards-seekers -- is due in part to its fee structure. Unlike most other banks that issue gift cards, Charter One doesn't levy any shipping charges or other upfront fees. Some other banks charge more than $10 in fees for a gift card on top of the actual amount loaded onto the card. Such fees offset the value of the rewards consumers earn. "It makes us the place to go for gift cards" and gives the bank a marketing boost with its other products, Mr. Grossi says.

Possible Snag

In the past, other banks have shut down similar avenues for earning miles after they discovered that mileage fanatics were racking up rewards. But Charter One says it has no intention of doing that. For one, the bank says it isn't paying for all these miles. Instead, it's the credit-card companies who issued the mile fanatics' reward cards that ultimately end up with the bill.

One possible snag has emerged. The bank recently put a $5,000 lifetime cap in place for people who bought cards repeatedly. But last week, Mr. Grossi said that consumers purchasing $5,000 or so in gift cards each month shouldn't have any problems, even though a cap of some sort is theoretically in place. Indeed, The Wall Street Journal in recent days purchased $7,500 in gift cards without encountering any roadblocks.

On Monday, Charter One said in an e-mailed statement that it has "implemented policies and actions to limit the number of Gift Cards and/or dollar amount of Gift Cards that an individual could order" online. It's also possible to purchase gift cards on the phone and at a bank branch.

A Lucrative Business

Banks are increasingly targeting the lucrative gift-card market. Last year, consumers spent $690 million on gift cards from Visa USA, MasterCard International, American Express and Morgan Stanley's Discover unit,according to the Nilson Report, a newsletter that tracks consumer-payments systems.

Though it was retailers that first popularized gift cards pre-loaded with money to spend on things like clothing and music, banks have picked up on the trend more recently. The banks can make money off the cards by charging fees when people buy the cards, use them at ATMs, or even when they don't use them enough; many banks charge inactivity fees, which are automatically subtracted from the balance when consumers let their cards sit around for too long.

While Charter One has no further plans to try to stymie the rewards seekers, at least one credit-card issuer has already cracked down. American Express in recent weeks has started to code Charter One gift-card purchases in a new way. They now count as cash advances, which can trigger additional fees and interest. Those fees can outweigh any rewards earned. American Express, like other card issuers, has to pay for every reward it gives to its cardholders, whether it's cash back or airline miles.

Triggering a Fraud Alert

If Visa and MasterCard issuers were to follow suit, the deal could end quickly. Many people buying the gift cards with credit cards are using Citibank plastic that offers a promotional rate of 5% cash back on purchases. A Citibank spokeswoman says that the bank doesn't plan to block gift-card purchasers from earning points at this time.

There are a couple of pitfalls to watch out for if you plan to try this method of earning more credit- or debit-card rewards. Repeatedly purchasing gift cards is likely to cause a fraud alert to go out on your card that could temporarily disable it. Just call your card company if this happens and tell the representative that you're buying bunches of gift cards and might do so again in the future. The issuer should be able to turn the fraud alert off.

Also, in the event that your card issuer quietly changes the coding for a Charter One gift-card purchase from "purchase" to "cash advance," you could get hit with fees and interest for using the cash-advance feature on your card.

You may be able to protect yourself from this, however, by calling your card company before they do this and telling them you want to disable the option to use the card for any cash advances.

That's what Nirlay Kundu did. The Sudbury, Mass., financial consultant simply called Citibank and lowered his cash-advance limit to zero. "You should be very careful," he says. "This way, if Visa or MasterCard decided to curtail this deal, I wouldn't be able to buy the gift card at all."

Write to Ron Lieber at ron.lieber@wsj.com