CHAPTER SEVEN

SLOT MANAGEMENT

SLOTS

In the casinos of the past, table games were king. Not only were table games the most popular, but they were also the most profitable. On the Las Vegas Strip, where table games once ruled, slots now dominate. Nearly 50% of the total casino win comes from slots. Statewide in Nevada, slots generate over 67% of the total casino win. The comparison is even more dramatic if you were to look at the departmental profits.

In the early days of gaming, slots were merely a diversion and were usually placed around the perimeter of the casino. These machines were all pretty much the same: three-reel mechanical slots. With the exception of the cabinetry, denomination, and brand name, the workings of the "one-armed bandits" were essentially the same. You inserted a coin, pulled the handle, and awaited the outcome as mechanical reels spun and clicked into position.

Themed Slots

Yesterday's mechanical slots have been replaced by today's electronic versions. Apart from the major technological advancements of the past 30 years, one of the most fundamental changes is the proliferation of themed slot machines featuring a mind-boggling assortment of television personalities, cartoon characters, game shows, board games, and other icons of popular culture. This new generation of heavily themed video and reel-spinning slots underscores the highly competitive nature of today's slot floor where bank upon bank of imaginative slots compete for the player's attention.

Las Vegas–based Bally Gaming and Systems is one of the leading slot manufacturers, marketing an array of gaming devices that feature a variety of well-known personalities: Blondie and Dagwood (Fig. 7.1), Popeye the Sailor Man (Fig. 7.2), Betty Boop (Fig. 7.3), and the Lone Ranger, to name just a few. The number of licensed titles introduced by Bally and its competitors has grown to more than 100 in recent years.

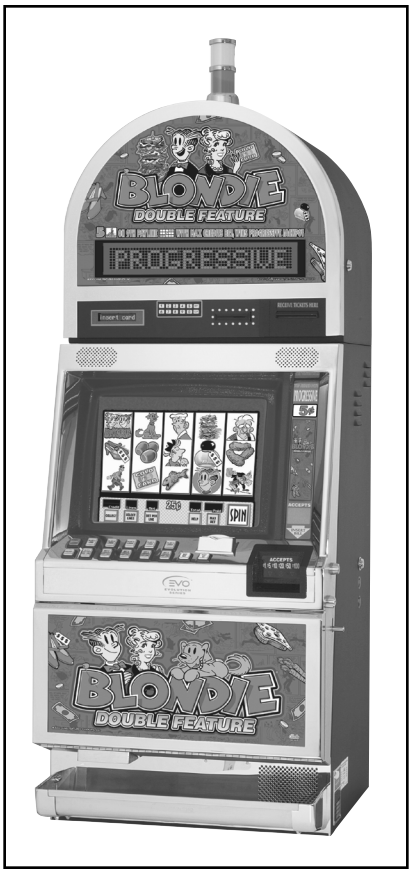

Figure 7.1 Blondie Double Feature Game (themed slot).
Source: © 2000 Bally Gaming, Inc.

Bonus "Game within a Game"

One of the most innovative features of today's slots is the "game within a game" feature. If a player hits specific symbols, the player then plays the "game within a game." Bally Gaming's Blondie and Dagwood slots actually have a double bonus feature. In the first, Dagwood crashes into Mr. Beasley, the mailman, scattering the contents of his mailbag and awarding bonus credits. The second bonus feature is more involved. Players choose to go shopping with Blondie or to help Dagwood build one of his renowned sandwiches by using the game's interactive touch-screen display. In either bonus, the player continues to accrue bonus credits until he unveils a "stopper" symbol.

Figure 7.2 Popeye's Bonus Frenzy Game (themed slot).
Source: © 2000 Bally Gaming, Inc.

The bonus feature on the Lone Ranger slot involves a daring chase across the badlands and a chance to collect trading cards for bonus credit. The principle of providing the player with an entertaining animated bonus round in which the player physically interacts with the game by touching the video monitor remains the same across all of its various forms.

The Cashless Casino

The trend in slot operations is toward the "cashless casino." Cashless slots can be configured to return coins and/or bar-coded tickets. The

Figure 7.3 Betty's World Tour Game (themed slot).
Source: © 2000 Bally Gaming, Inc.

player can then take his ticket to another slot machine or cash it out at the change booth. Bally Gaming's technology also allows the player to deposit money with the casino cage, where the player is then given a magnetically imprinted card. Using a secure personal identification number (PIN), the player can then access his money by inserting his card into the slot machines.

Participation Games and Pricing Strategies

There are a variety of ways a casino can obtain slot machines. In the early 1990s, the "shelf life" of the typical slot machine was eight to ten years. Today the typical slot machine life is two to three years, with video reels

experiencing shelf lives as brief as six to nine months in certain markets. The shrinking shelf life is due to decreases in demand rather than mechanical issues. Consequently, casinos actively seek alternative pricing options.

In the traditional sense, casinos buy most machines outright directly from the manufacturer at prices ranging from $7,000 to $10,000 for a typical reel-spinning or video slot. Game conversion kits ranging in price from $250 to $2,000 can be used to turn an existing machine into a brand-new title (i.e., machine type).

Depending on the title, casinos can also lease and/or lease/purchase slot machines. With a lease/purchase, the amount of the lease/purchase payment is ultimately applied toward the purchase of the machine. There is also a daily-fee option on licensed titles whereby the operator pays the manufacturer a daily fee, say $25 per game per day, in addition to up-front charges for the machines.

An increasingly popular alternative is to enter into participation agreements with slot manufacturers. Under this arrangement, the slot manufacturer provides slot machines to the casino with no up-front costs. The casino and the manufacturer then share in the revenue generated by the machines, based on a predetermined percentage, such as an 80/20 split whereby 80% goes to the casino and 20% to the manufacturer. Many of the most popular titles are offered to casinos exclusively as participation games. For casinos, participation agreements can offer favorable acquisition terms for certain machines such as video reels, for which life cycles are sometimes measured in months instead of years. Casino operators may be able to offer the latest and most popular games without straining their capital budgets.

Types of Slots

There are three major categories of slot machines:

- Line Games
- Multipliers
- Buy-a-Pays

Line games allow the player to "activate" additional lines with each coin inserted. The player will see three symbols "in the glass" for each reel. A three-reel line game would look like the following:

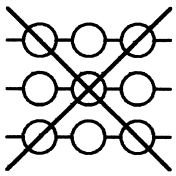

Figure 7.4 shows an example line game. As many as five different pay lines can be activated.

Multipliers are games that pay on the center horizontal line only. As additional coins are inserted, multipliers "multiply" the payout per coin. For example, one cherry on the pay line might pay two coins with one coin inserted and ten coins with five coins inserted. See Fig. 7.5 for an example.

Buy-a-pay games pay on the center horizontal line only, but the player is allowed to "buy" additional jackpot symbols. For example, the only symbols that pay with one coin inserted might be the single bars, double bars, triple bars, and any bars. With a second coin inserted, Red 7s and Sizzling 7s will pay in addition to the bars that were bought with the first coin. On a buy-a-pay, the player would receive nothing if the three Sizzling 7s were lined up on the center pay line with only one coin inserted. Figure 7.6 provides an example of the award glass for buy-a-pay games.

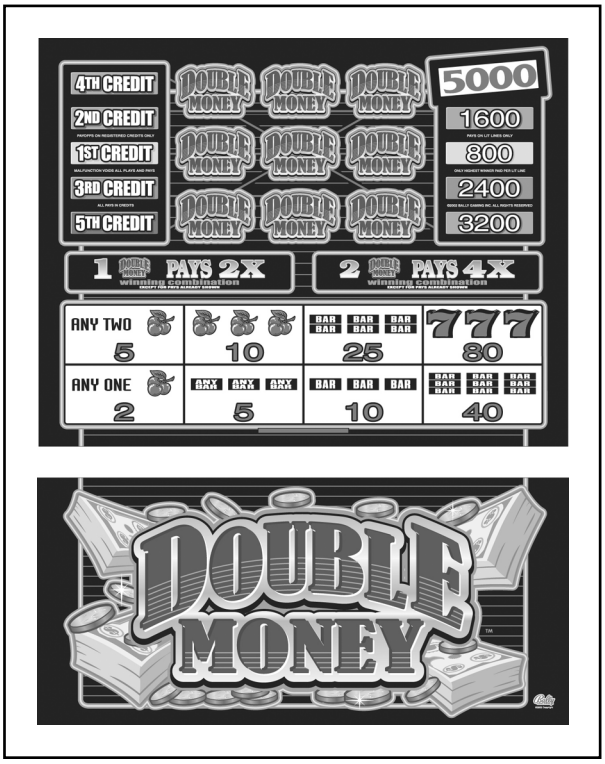

Figure 7.4 Line Game. ***Source:*** © 2000 Bally Gaming, Inc.

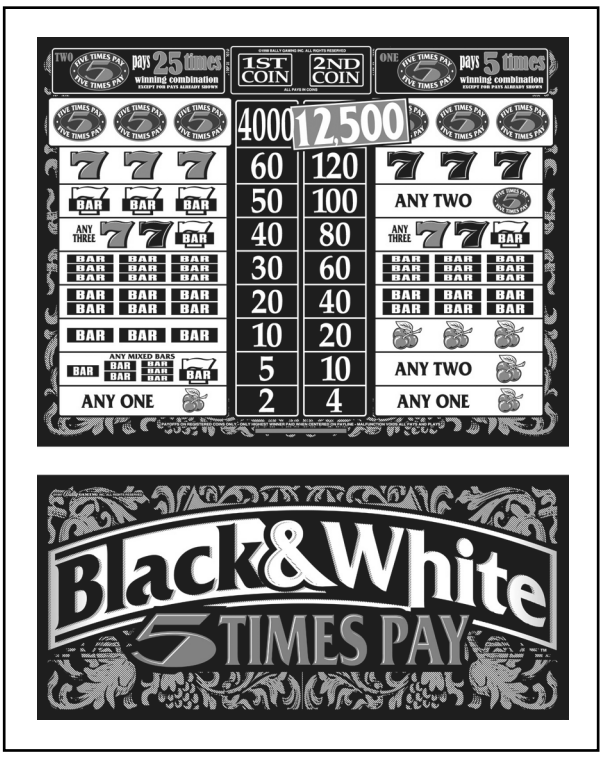

Figure 7.5 Multiplier Game. ***Source:*** © 2000 Bally Gaming, Inc.

Slot Terms

There are a myriad of terms that apply to the operation and management of a slot department. The following list discusses several of the most common terms encountered in the day-to-day operation of a slot department.

1. *Coin-in*. Unlike the table games, in which the only information known to the casino is how much the player bought in at the table, slot machines include meters that indicate the total amount inserted into the machine. As each coin is inserted, the coin-in meter advances and maintains a cumulative total for all coins inserted into the machine. This coin-in feature allows management to monitor exactly what percentage the machine is winning and then compare that percentage with the game's theoretical win percentage. The coin-in feature also allows management to monitor the volume of play for a machine in order to evaluate the popularity of the machine with slot players.

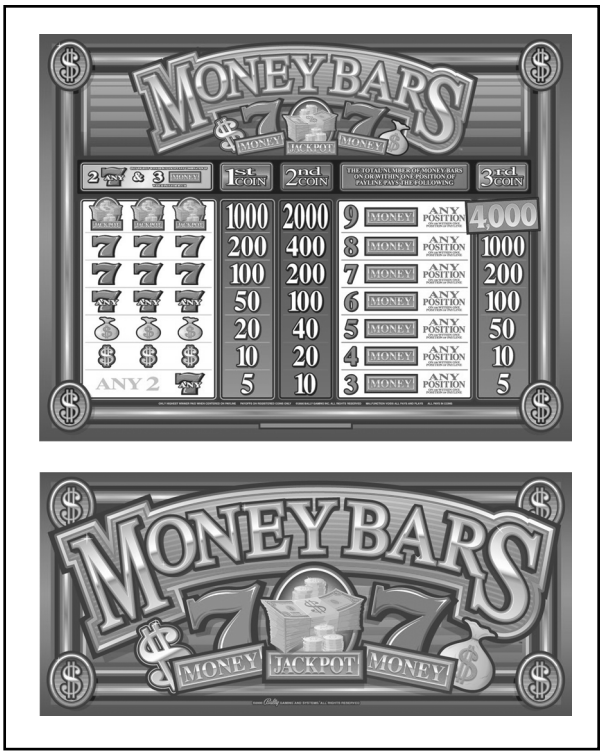

Figure 7.6 Buy-a-Pay Game. ***Source:*** © 2000 Bally Gaming, Inc.

2. *Hopper.* Each slot machine utilizing coin has an internal bank called a hopper. All machine pays are made through this hopper, which works much like the tank on a water closet or toilet. When the tank gets full, a float stops the water flow. Management determines the amount the hopper will hold, and once the predetermined amount is reached, any additional coin-in is diverted to the drop bucket located in the slot stand directly below the slot machine. Figure 7.7 shows an example of a typical slot machine.
3. *Drop.* Any coins inserted into the slot machine when the hopper is full are diverted to a bucket below the slot machine. The total amount of coin in this bucket is called the drop.
4. *Casino Advantage (par).* The percentage of each dollar wagered that the house wins is called the casino advantage. The casino advantage is a theoretical amount, but the actual percentage will approximate the theoretical advantage after a large number of games are played. The number of games that must be played for the actual percentage to approximate the theoretical varies, based on the slot machine type and configuration.

Figure 7.7 Slot Diagram. ***Source:*** © 2000 Bally Gaming, Inc.

5. *Hold (actual).* Since slot machines have the capability of providing total coin-in, management is able to calculate the percentage of the total wagered that is actually won by the slot. This calculation is called the hold.
6. *Progressive.* Progressive slots allow for what is called a "deferred" payout. For example, the progressive meter might advance four

cents for every dollar inserted into the machine. This four-cent advancement represents four cents the "public" has just won. The increments accumulated in the progressive amount displayed by the machine(s) will be held by the casino until some lucky player lines up the jackpot symbols that result in the progressive amount being paid.

MegaBucks, Nevada Nickels, and Quartermania are examples of progressive slot machines. Each casino will also have progressives of its own, and progressives of this type can be found in casinos around the world.

7. *Linked Progressive.* Linked slot machines all share the same progressive meter. As a coin is inserted into a single machine, the progressive meter on all of the machines increases. The largest linked progressive jackpot ever paid was on International Game Technology's (IGT's) MegaBucks. MegaBucks includes almost 1,000 machines located in various parts of Nevada that are all linked through a central computer system located in Reno. This type of linked progressive was developed as Nevada's answer to the California lottery, since Nevada does not have a state lottery. Linked progressives of the type represented by MegaBucks have now become common to many other gaming jurisdictions in the United States where slot machines are permitted.
8. *Progressive Accrual.* Until the progressive jackpot is won, the amount on the progressive meter is held in escrow by the casino for the player who wins the progressive jackpot. Any amount reflected on the progressive meter is recorded by the casino as a liability. Since progressive jackpots may vary substantially in the dollar amount and frequency of payout, casinos may establish a threshold below which they will not record the progressive amounts as a liability for financial accounting purposes.
9. *Machine Fill.* Like table games, slot machines will run out of money at times. When the hopper goes empty, it must be replenished. This replenishment is known as a fill.
10. *Handpay.* On large jackpots, the hopper in the slot machine does not contain enough coins to make the payout. As a result, slot machines are designed to require management participation to complete the payout on large jackpots. These payouts are known as handpays. For example, a player would receive the payout in the form of a handpay if she were to hit MegaBucks for $3.8 million.
11. *Hit Frequency.* The percentage of pulls that the machine pays at least one coin is known as the hit frequency and is expressed as a percentage. A machine with a 20% hit frequency will pay something 20 times out of 100 times the handle is pulled.

$$\text{Hit Frequency} = \frac{\text{Expected number of pulls resulting in a 1 or more coin payout in a cycle}}{\text{Number of pulls in a cycle}}$$

Slot mix is the term that describes the quantity, type, denomination, and strategic placement of machines that management has chosen to offer the public. The variables that constitute the slot mix are:

- Model mix
- Mechanical configuration
- Floor configuration

Model Mix

Slot machines come in line games, multipliers, and buy-a-pays. They are available in either video or mechanical types. Although video poker is not called a slot (it is actually called video poker), it does qualify as a model option. In addition, there are numerous specialty games, including blackjack, keno, bingo, dice, horse racing, and dog racing. Almost every game is available as a stand-alone or linked progressive.

Each reel game is available as an upright game or slant top. Video pokers are available as uprights, slant tops, or bar tops.

Slot machine popularity differs from casino to casino and target market to target market. For example, the casinos in Las Vegas that cater to local customers offer predominantly video poker machines, whereas the Strip casinos catering to tourists have primarily reel-type slots. One reason for the difference in preference seems to be the level of sophistication of the gambler. Local customers seem to be more astute gamblers, who know that video poker machines may have a lower casino advantage. In addition, video poker machines involve a thought process whereby the player must make certain decisions. With reel slot machines, the only decisions the player makes is which machine to play and how many coins to bet.

Mechanical Configuration

Elements of mechanical configuration include coin denomination, payoff schedule/reel strip combination, casino advantage, and hit frequency. The slot manager must decide the number of machines of each denomination to offer and where the different denominations should be placed. When planning to open a casino, in order to determine the initial slot mix, management would first identify the customer base to be targeted and then prepare an analysis of what competitors have chosen to offer their customers. If certain competitors are identified as being successful in reaching the customer base targeted, management may consider duplicating the competitor's mix initially. Once the casino is open, the slot data would be analyzed and used to modify the mix of machines.

What mix should be used for a new gaming market? New gaming markets present a special challenge for the casino operator, since historical information does not exist relevant to customers and competitor performance in the market.

In practice, where the market is developed, the games and denominations offered will vary significantly. Within a given market, the mix will vary from target market to target market. For example, the primary customer target market of the Mirage and Caesars Palace is the tourist, while Sam's Town and Palace Station target the local gambler.

Why the difference? As mentioned previously, local customers are generally more sophisticated players and video poker machines tend to be attractive to a higher level of gambling sophistication. Video poker machines provide a lower casino advantage, a hit frequency of about 50%, and require the player's interaction.

Locals do not start out as more sophisticated players. Their more frequent play leads to increased knowledge. When Colorado gaming was first introduced, the target market was primarily local customers (locals) from the Denver area, and Las Vegas's experience had shown that locals prefer video poker. However, the Denver locals were not as familiar with gaming or as sophisticated as the Las Vegas locals. Consequently, a mix with a high percentage of video poker machines was not successful in this market, as the locals showed a preference for reel-type slots. Over time, video poker machines will likely represent an increasing percentage of the total machine population.

Payoff Schedule/Reel Strip Combinations There are two primary types of reel strips: ghost strips and fruit strips. The names are somewhat misleading, in that ghost strips can contain fruit symbols. Fruit strips contain a symbol for every possible stop on the reel. For example, a 20-stop fruit strip would contain 20 symbols.

On the other hand, ghost strips have fewer symbols than stops. A 20-stop ghost strip can have 11 symbols and 9 ghosts; ghosts allow the reel to stop between symbols. Ghost strips are by far the most popular in today's market. Over 95% of the total slot machines sold in the United States contain ghost strips. When the Gold Coast opened in Las Vegas, the casino included 900 machines. Six hundred of these machines were video poker and 300 were slot machines. Of the 300 slots, only 6 were fruit-strip machines.

Casino Advantage Casino management must select games at house advantages that result in the most profit. Slot machine advantages range from as low as 0.5% to as much as 25%. However, higher house advantages do not necessarily result in the highest win. Many casino operators advertise low-advantage machines in the belief that the decrease in house advantage will be more than offset by the increase in volume.

Many gaming jurisdictions have established minimum levels at which slot machines must pay back in order to prevent casino operators from placing players at too great a disadvantage. Atlantic City gaming regulations require that slot machines must pay back at least 83%, which means a 17% advantage for the casino. Nevada Gaming Regulation 14.04 states that machines must theoretically pay out a mathematically demonstrable percentage, per coin wagered, of at least 75%.

Hit Frequency The percentage of trials that the machine pays something to the player is referred to as its hit frequency. Conventional management philosophy is that high hit frequency machines stimulate play. When purchasing slot machines, management must first choose the particular model, then the desired casino advantage, and finally the hit frequency. Hit frequencies range anywhere from single digits to the high 30% range for multipliers and buy-a-pays. Hit frequencies for line games can exceed 100%.

Physical/Expanded Reel The reels on today's slot machines appear to stop mechanically, much like their predecessors. In actuality, the reels stop and display the symbol according to what was chosen by the slot machine's internal computer chip, which is known as an EPROM (erasable, programable read-only memory). As a result of this advancement in technology, it is no longer necessary to physically place the same number of symbols on the reels as is possible on the "computer reel."

When computerized slot machines were first introduced, they were equipped with a video terminal that displayed a picture that was designed to give the appearance of slot machine reels. However, the playing public realized that the video reels could have hundreds or even thousands of symbols, since they could not see the actual size of the reels. As a result, customers believed that they had little chance of hitting the jackpot. Later, the slot machine manufacturers found they could incorporate the same technology in machines with actual spinning reels.

Today's machines have physical spinning reels, but the symbol where the reel stops is determined by computer. This new type of electronic machine with spinning reels is called a "stepper slot." There is little relation between the physical reel and the possibilities available to the computer. It is only necessary to put one of each symbol on the physical reel, but in this case the playing public would probably become suspicious.

The slot machines being supplied today offer the best of both worlds: (1) players feel that they have a good chance of hitting the jackpot and (2) the slot machine can have an infinite number of reel strip/payout combinations that provide large jackpots. If not for this technology, million-dollar slot jackpots would not be possible.

PC Sheet (game sheet, specification sheet, theoretical hold worksheet) PC (par calculation) sheets are prepared by the manufacturer and are sup-

plied to the casino operator at the time the slot machines are purchased. Gaming regulations in Nevada and many other gaming jurisdictions require that a PC sheet be maintained for every slot machine or type of slot machine. The PC sheet lists the machine's model number, paytable number, each pay combination and hit frequency, reel strip listing, and theoretical hold percentage (i.e., casino advantage).

The reel strip listing includes both the physical listing that the player would see if the strip were taken off the reel, and the expanded listing that details what symbols are available for random selection by the machine's computer. Figure 7.8 depicts an example of a three-reel, two-coin multiplier's PC sheet and reel strip listing.

VIDEO POKERS

Table 7.1 lists the probabilities for video poker. The first game's lowest pay is a pair of Jacks or better, the Full House pays seven coins, and the Flush pays five coins. The "total" column assumes the best play possible. The correct way to play the hands is determined by the pay table. As the pay table changes, the way the hands are played must change in order for play to be optimized.

On the 7/5 pay schedule, the optimum player return is 96.1% at maximum coins-in and 94.73% at one coin-in. Naturally, every player will not play maximum coins or play the game perfectly. Consequently, the hold the casino should expect is between 2% and 4% more than optimum play. On the 7/5 schedule, the optimum return is 96.1%, but the actual expected casino payback to the player should be between 92.1% and 94.1%.

The slot manager has several different types of video pokers from which to choose. Video poker choices are

- Jacks or Better
- Tens or Better
- Deuces Wild
- Joker Poker (one joker serves as a wild card)
- Deuces-Joker Wild

Each type of video poker comes in a variety of pay tables that offer a choice of casino advantages. Figure 7.9 provides an example of a typical video poker machine.

Slot Volatility

Slot Machine Volatility Although each machine has a fixed casino advantage, the actual hold can vary drastically from the theoretical advantage. The PC sheet for the reel-type machine included previously in this

IN THE MONEY **2 COIN OPTION BUY**
ART–ITM **MAX COIN % = 91.99%**
SMI–9662 **MIN COIN % = 91.03%**

SYMBOLS			FACTORS			TOTAL		ACTUAL	1st COIN	2nd COIN	1st COIN	2nd COIN
R1	R2	R3	R1	R2	R3	HITS	MINUS	HITS	PAYS	PAYS	OUT	OUT
R7	R7	R7	1	1	1	1		1	1000	2000	1000	2000
G7	G7	G7	6	6	4	144		144	100	100	14400	14400
5X	5X	5X	3	1	1	3		3	1000	1000	3000	3000
3B	5X	5X	8	1	1	8		8	500	500	4000	4000
5X	3B	5X	3	7	1	21		21	500	500	10500	10500
5X	5X	3B	3	1	5	15		15	500	500	7500	7500
2B	5X	5X	8	1	1	8		8	375	375	3000	3000
5X	2B	5X	3	9	1	27		27	375	375	10125	10125
5X	5X	2B	3	1	8	24		24	375	375	9000	9000
1B	5X	5X	8	1	1	8		8	250	250	2000	2000
5X	1B	5X	3	11	1	33		33	250	250	8250	8250
5X	5X	1B	3	1	8	24		24	250	250	6000	6000
5X	3B	3B	3	7	5	105		105	100	100	10500	10500
3B	5X	3B	8	1	5	40		40	100	100	4000	4000
3B	3B	5X	8	7	1	56		56	100	100	5600	5600
5X	2B	2B	3	9	8	216		216	75	75	16200	16200
2B	5X	2B	8	1	8	64		64	75	75	4800	4800
2B	2B	5X	8	9	1	72		72	75	75	5400	5400
5X	1B	1B	3	11	8	264		264	50	50	13200	13200
1B	5X	1B	8	1	8	64		64	50	50	3200	3200
1B	1B	5X	8	11	1	88		88	50	50	4400	4400
*MU	*MU	*MU	18	18	17	5508		5508	0	62.81	0	345930
3B	3B	3B	8	7	5	280		280	20	20	5600	5600
A7	A7	A7	7	7	5	245	−145	100	20	20	2000	2000
2B	2B	2B	8	9	8	576		576	15	15	8640	8640
1B	1B	1B	8	11	8	704		704	10	10	7040	7040
5X	XB	XB	3	27	21	1701	−585	1116	25	25	27900	27900
XB	5X	XB	24	1	21	504	−168	336	25	25	8400	8400
XB	XB	5X	24	27	1	648	−216	432	25	25	10800	10800
XB	XB	XB	24	27	21	13608	−1560	12048	5	5	60240	60240
CH	CH	CH	2	2	2	8		8	10	10	80	80
CH	CH	NC	2	2	70	280		280	5	5	1400	1400
CH	NC	CH	2	70	2	280		280	5	5	1400	1400
NC	CH	CH	70	2	2	280		280	5	5	1400	1400
CH	NC	NC	2	70	70	9800		9800	2	2	19600	19600
NC	CH	NC	70	2	70	9800		9800	2	2	19600	19600
NC	NC	CH	70	70	2	9800		9800	2	2	19600	19600
Totals						55307	−2674	52633			339775	686705

Figure 7.8 (a) Par Sheet and Reel Strip Listing. ***Source:*** © 2000 Bally Gaming, Inc.

IN THE MONEY
ART–ITM
SMI–9662

2 COIN OPTION BUY
MAX COIN % = 91.99%
MIN COIN % = 91.03%

COINS	TOTAL HITS	TOTAL OUT	TOTAL IN	HIT %	PAY %
1	47125	339775	373248	12.63%	91.03%
2	52633	686705	746496	14.10%	91.99%

In The Money Feature	
Hits	5508
Avg. Pay	62.81
Pulls Per	67.76

MAX COIN PAYS	TOTAL HITS	% OF TOTAL HITS	% OF TOTAL OUT	PLAYS PERHIT	P/H AND HIGHER
2000	1	0.00%	0.29%	373248	373248
1000	11	0.02%	1.64%	33142	30439
500	61	0.11%	4.41%	6167	5128
400	22	0.04%	1.28%	16941	3936
375	59	0.11%	3.22%	6326	2427
350	17	0.03%	0.84%	22588	2191
300	8	0.02%	0.36%	45176	2090
280	22	0.04%	0.90%	16941	1860
260	25	0.05%	0.94%	15059	1656
250	65	0.12%	2.37%	5742	1285
240	22	0.04%	0.77%	16941	1195
220	22	0.04%	0.71%	16941	1116
200	22	0.04%	0.64%	16941	1047
180	25	0.05%	0.65%	15059	979
160	17	0.03%	0.39%	22588	938
140	17	0.03%	0.34%	22588	901
120	17	0.03%	0.29%	22588	866
110	11	0.02%	0.18%	33882	845
100	620	1.18%	9.03%	602	351
90	330	0.63%	4.33%	1129	268
80	303	0.58%	3.53%	1232	220
75	352	0.67%	3.84%	1060	182
70	551	1.05%	5.61%	678	144
60	661	1.26%	5.78%	565	115
50	1270	2.41%	9.25%	294	82
40	826	1.57%	4.81%	452	70
30	840	1.60%	3.67%	444	60
25	1884	3.58%	6.86%	198	46
20	972	1.85%	2.83%	384	41
15	576	1.09%	1.26%	648	39
10	718	1.36%	1.04%	520	36
5	12888	24.49%	9.38%	29	16
2	29400	55.86%	8.56%	13	7
		100.00%	100.00%		

Winfunctional will show a max of 91.40% due to an avg. pay of 62.00.

Winfunctional will show a 2 coin hit % of 15.47% due to anticipation sounds.

Figure 7.8 (b) Par Sheet and Reel Strip Listing. ***Source:*** © 2000 Bally Gaming, Inc.

IN THE MONEY
ART–ITM
SMI–9662

2 COIN OPTION BUY
MAX COIN % = 91.99%
MIN COIN % = 91.03%

HANDLE PULLS		90% CONFIDENCE FACTOR	LOWER LIMIT	UPPER LIMIT
1000		38.589	53.40%	130.58%
10000	V.I. =	12.203	79.79%	104.19%
100000		3.859	88.13%	95.85%
1000000		1.220	90.77%	93.21%
10000000		0.386	91.60%	92.38%

	SYMBOLS	R1	R2	R3
R7	Red Seven	1	1	1
G7	Gold Seven	6	6	4
5X	Five Times Bar	3	1	1
MU	In The Money Feature	12	12	11
MB	In The Money Special Blank	6	6	6
3B	Triple Bar	8	7	5
2B	Double Bar	8	9	8
1B	Single Bar	8	11	8
CH	Cherry	2	2	2
BL	Blank	18	17	26
	Total	72	72	72
	Total Combinations		373248	
XB	Any Bar (3B,2B,1B)			
A7	Any Seven (R7,G7)			
NC	Any symbol or blank except a cherry			
	*denotes a scatter pay			

Figure 7.8 (c) Par Sheet and Reel Strip Listing. ***Source:*** © 2000 Bally Gaming, Inc.

chapter has a return, at maximum coins bet, of 91.99%. However, the casino can expect to be returning between 53.40% and 130.58%[1] (holding between 46.60% and -30.58%) at 1,000 games played. As the number of games played increases, the actual hold will more closely approximate the machine's theoretical hold. At 10 million games played, the same machine will return between 91.60% and 92.38% (holding between 8.40% and 7.62%).

The amount the actual hold varies from the theoretical hold is a function of the machine's volatility index. Each machine has its own volatility

Table 7.1 Video Poker Game Sheet and Optimum Play Results

	7/5 Schedule						
				ONE COIN		5th COIN BONUS	
	DEALT	*BUILT*	*TOTAL*	*PAYS*	*COIN-OUT*	*PAYS*	*COIN-OUT*
ROYAL FLUSH	4	60.7141	64.7141	250	16,178.5250	4000	258,856.4000
STRAIGHT FLUSH	36	244.1679	280.1679	50	14,008.3950	250	70,041.9750
FOUR-OF-A-KIND	624	5,515.0034	6,139.0034	25	153,475.0850	125	767,375.4250
FULL HOUSE	3,744	26,172.3687	29,916.3687	7	209,414.5809	35	1,047,072.9045
FLUSH	5,108	23,230.2802	28,338.2802	5	141,691.4010	25	708,457.0050
STRAIGHT	10,200	19,120.9469	29,320.9469	4	117,283.7876	20	586,418.9380
THREE-OF-A-KIND	54,912	138,532.4912	193,444.4912	3	580,333.4736	15	2,901,667.3680
TWO PAIR	123,552	211,745.0154	335,297.0154	2	670,594.0308	10	3,352,970.1540
JACKS OR BETTER	337,920	221,091.8658	559,011.8658	1	559,011.8658	5	2,795,059.3290
TENS OR BETTER	422,400						
Less than pair 10s	1,640,460						
TOTALS	2,598,960				2,461,991.1447		12,487,919.4985
				COIN-IN	2,598,960.0000		12,994,800.0000
				COIN-OUT	2,461,991.1447		12,487,919.4985
				WIN	136,968.8553		506,880.5015
				%ADV.	5.27%		3.90%
				%RETURN	94.73%		96.10%

	10's or Better				9/6 Schedule			8/5 Schedule		
	DEALT	*PAYS*	*BUILT*	*TOTAL*	*PAYS*	*BUILT*	*TOTAL*	*PAYS*	*BUILT*	*TOTAL*
ROYAL FLUSH	4	300	70.8500	74.8500	250	60.4542	64.4542	250	60.7141	64.7141
STRAIGHT FLUSH	36	50	259.7616	295.7616	50	248.0663	284.0663	50	243.9080	279.9080
FOUR-OF-A-KIND	624	25	5,442.7523	6,066.7523	25	5,516.0430	6,140.0430	25	5,517.0826	6,141.0826
FULL HOUSE	3,744	9	25,894.2799	29,638.2799	**9**	**26,175.7473**	**29,919.7473**	**8**	**26,179.6458**	**29,923.6458**
FLUSH	5,108	6	23,559.0486	28,667.0486	**6**	**23,518.2449**	**28,626.2449**	**5**	**23,224.8223**	**28,332.8223**
STRAIGHT	10,200	4	24,213.3492	34,413.3492	4	18,984.7614	29,184.7614	4	18,999.5755	29,199.5755
THREE-OF-A-KIND	54,912	3	135,487.5497	190,399.5497	3	138,577.1934	193,489.1934	3	138,613.5788	193,525.5788
TWO PAIR	123,552	1	208,022.2772	331,574.2772	2	212,438.6899	335,990.6899	2	212,489.3697	336,041.3697
JACKS OR BETTER	337,920				1	219,777.8316	557,697.8316	1	221,039.8866	558,959.8866
TENS OR BETTER	422,400	**1**	**232,260.3511**	**654,660.3511**						

Figure 7.9 (a) Video Poker. ***Source:*** © 2000 Bally Gaming, Inc.

index, which is influenced by the total number of pays, the size of the pays, and the machine's theoretical payback. Management must be familiar with the concept of slot volatility and must know exactly how unusual the results they are experiencing are prior to determining whether something is wrong with a particular machine's hold.

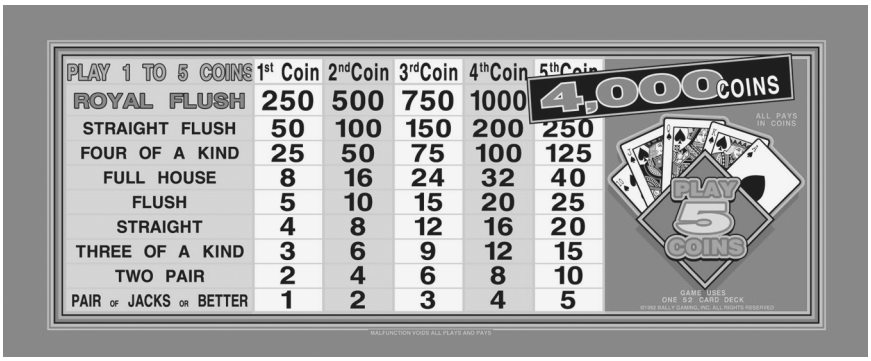

Figure 7.9 (b) Video Poker. ***Source:*** © 2000 Bally Gaming, Inc.

In practice, casino management should investigate a machine if the actual hold of the machine is outside a range of acceptability as determined by the number of games played and the machine's volatility index.

Calculating Slot Volatility The formula for the volatility index (V.I.) is

$$\text{V.I.} = k\sigma$$

where k equals the z score for the required confidence limit and σ equals the standard deviation for the game.

The game's standard deviation is calculated as follows:

$$\sigma = \sqrt{\sum_{i=0}^{N} [(\text{Net Pay}_i - \text{E.V.})^2 \times \text{probability}_i]}$$

Net Pay_i = the amount of each individual pay divided by the number of coins wagered *minus* 1; e.g., a 25-coin pay with 2 coins wagered equals 12.5 *minus* 1 *equals* 11.5.

E.V. = player's theoretical disadvantage for "x" coins wagered; i.e., in the aforementioned machine, the player's disadvantage with one coin wagered is 8.97%, and 8.01% with two coins wagered.

probability = probability of each Net Pay

Given the reel strip listing and the pay table, the slot machine's volatility can be calculated. Assume the following reel strip listing and pay table:

Reel Strip Listing

Symbol	*Reel 1*	*Reel 2*	*Reel 3*
~	17	19	21
1B	9	7	6
5B	4	4	3
7B	1	1	1
JW	1	1	1

Legend:
"~" blank
"1B" single bar
"5B" 5 bar
"7B" 7 bar
"JW" Joker Wild

Pay Table

Pay Combination			*Pays*
JW	XX	XX	2
XX	JW	XX	2
XX	XX	JW	2
JW	JW	XX	5
JW	XX	JW	5
XX	JW	JW	5
AB	AB	AB	5
1J	1J	1J	10
5J	5J	5J	50
7J	7J	7J	200
JW	JW	JW	400

"AB" Any bar
"1J" single bar or Joker Wild
"5J" 5 bar or Joker Wild
"7J" 7 bar or Joker Wild

The preceding reel strip listing and pay table create a game with the following machine nets and frequencies of each:

Pay Combination			*Pays*	*Machine Nets*	*# of Hits*
JW	XX	XX	2	−1	841
XX	JW	XX	2	−1	821
XX	XX	JW	2	−1	793
JW	JW	XX	5	−4	21
JW	XX	JW	5	−4	19

Pay Combination			*Pays*	*Machine Nets*	*# of Hits*
XX	JW	JW	5	−4	17
AB	Ab	AB	5	−4	1,479
1J	1J	1J	10	−9	559
5J	5J	5J	50	−49	99
7J	7J	7J	200	−199	7
JW	JW	JW	400	−399	1
Losing combination			−1	+1	28,111
Total Hits					32,768

With one coin played, the machine has pays of minus 1 (when the player loses); two for 1; five for 1; ten for 1; fifty for 1; two hundred for 1; and four hundred for 1. There are a total of 28,111 minus one hits; 2,455 *two* for 1 hits (841 + 821 + 793); 1,536 *five* for 1 hits; 559 *ten* for 1 hits; 99 *fifty* for 1 hits; 7 *two hundred* for 1 hits; and 1 *four hundred* for 1 hits. The respective casino Net Pays are: –1; –4; –9; –49; –199; –399; and 1.

A	**B**	**C**	**D**	**E**	**F**	**G**
Net Pay	*# of Hits*	*Probability*[2]	*Expected Value*[3]	*A–D*	E^2	*CxF*
1	28,111	0.85787964	0.2392	0.76080	0.578	0.496559
−1	2,455	0.0792065	0.2392	−1.23919	1.535	0.115049
−4	1,536	0.04687500	0.2392	−4.23919	17.970	0.842381
−9	559	0.1705933	0.2392	−9.23919	85.362	1.456231
−49	99	0.00302124	0.2392	−49.23919	2424.498	7.324992
−199	7	0.00021362	0.2392	−199.23917	39696.257	8.480035
−399	1	0.00003052	0.2392	−399.23917	159391.936	4.864256
Total Hits = 32,768						Variance = 23.579504

$$\sigma = \sqrt{\sum_{i=0}^{N} [(\text{Net Pay}_i - \text{E.V.})^2 \times \text{probability}_i]} = \sqrt{23.579504} = 4.8559$$

At a 90% confidence interval, the Volatility Index (with one coin-in) would equal

$$\text{V.I.} = k\sigma = 1.65 \times 4.8559 = 8.01219$$

The 1.65 corresponds to the *z* score that comprises 90% of the area under the normal curve, which produces a V.I. of 8.01219. A 95% confidence interval would require a *z* score of 1.96.

To determine the upper and lower limits for a given number of games played, use the following formula:

$$\text{Percent payback} \pm \frac{V.I.}{\sqrt{\text{games played}}}$$

FLOOR CONFIGURATION

Once the slot manager has determined the machines needed, the next task is to decide where the machines should be placed on the casino floor. The placement of the machines is known as the floor configuration. Floor configuration considers both general placement and specific placement.

General placement deals with where the slot banks and coin booths will be placed. Slot banks refer to groupings of slot machines, whereas coin booths and slot carousels are areas on the casino floor where players can purchase coins and tokens for use in the slot machines.

In considering general placement, each slot cabinet that will hold a slot machine must be viewed as an empty box. These "empty boxes" can be used to create traffic patterns or, conversely, to impede traffic patterns. The overriding consideration is to place the machines where the maximum number will be viewed by slot players. Enticements such as the showroom, bingo parlor, keno parlor, casino bars, race and sports books, and restaurants create traffic. These enticements (sometimes called anchors) influence slot placement. For example, slot machines should be placed at the entrance and exit of the bingo parlor or showroom in such a manner that customers exiting will be exposed to the maximum number of machines.

Aisle Width Generally, slot aisles are between 5½ and 7 feet in width. Aisles that are too narrow cramp the customer and may have a negative impact on profit maximization. The extent of seating the slot manager decides to make available will determine the aisle width necessary. An additional consideration is that wider aisles provide less room for machines, since the area dedicated to slot machines within the casino floor is fixed.

From 1931 to the late 1970s, casino operators paid little attention to the slot player's desire to sit while playing. Today, the availability of seating is crucial to the success of a slot operation. In Atlantic City, regulations require all aisles to be at least 7 feet wide and only fixed seating can be provided. This fixed seating rule results from concerns that movable seats could impair the customer from exiting in the event of a fire. The fire marshals in this jurisdiction believe that the movable seats could topple over and trip exiting guests.

In Nevada, use of fixed or movable seating is left to the discretion of management. Surprisingly, fixed seating carries with it some liability and

safety issues. There have been several accidents resulting from the improper reattachment of fixed seats. For example, graveyard shift cleaning crews remove the seats to clean around the machine base and do not properly reattach them. Because of its single-stem construction, when a customer sits in the seat it becomes immediately unstable, causing the player and the seat to topple. Several patrons have been injured in such incidents in Nevada, causing casino operators to shy away from fixed seating. Movable seating provides the slot manager more flexibility and requires less aisle width, thereby increasing the room for slot machines on the casino floor. Movable seating also allows a player to stand if desired.

Specific placement deals with placement of the specific models and coin denominations. There are several general philosophies that influence specific slot placement:

1. Low hold (loose) machines should be placed in busy walkways to create an atmosphere of activity.
2. Loose machines are normally placed at the beginning and end of traffic patterns.
3. The most popular machines should be placed near entrances where they can easily be seen by someone trying to decide whether or not to enter the casino.
4. High hit frequency machines located around the casino pit area will create an atmosphere of slot activity.
5. Some slot managers believe that "garbage" machines should be placed in areas that are less attractive to players, such as the entrance to the rest rooms. Garbage machines refer to machines that are popular with the slot player but provide a low return to the casino.
6. Machines should be placed near compatible enticements. For example, keno machines should be placed next to keno, poker machines next to poker, etc.
7. High earners and test machines should be placed in heavy traffic areas.
8. Gimmick machines (machines in which the top award is a prize like a new car or a trip around the world) should be placed near entrances and in high traffic areas.
9. Dollar machines and above should be placed around the pit area, and nickel machines placed at the perimeter (placement by denomination).

These are only general philosophies governing slot placement. In application, the slot manager will continue to modify the slot floor configuration to best attract and retain customers through the use of available slot performance data.

Results from empirical studies indicate that machines with locations characterized by accessibility, visibility (i.e., located near major walkways), and close proximity to the pit areas, outperform like-kind counterparts (Lucas & Roehl, 2002; Lucas, Dunn, Roehl, & Wolcott, 2003). This stream of research is in its infancy, as the authors are aware of only two published studies related to the effects of machine location on unit-level performance. However, both of these studies produced statistically significant effects for categorical variables representing sections of the slot floor with substantial pit borders. These sections were also usually located in or near the core area of the casino floor.

A third, unpublished, proprietary study also empirically supported the results of the published research. Reel slots bordering major traffic aisles and pits were found to produce significantly greater amounts of coin-in than their less-accessible counterparts. Additionally, categorical variables representing end-units and ceiling height produced significant and positive model effects on coin-in levels. An end-unit was defined as any machine positioned at the end of a bank of machines. This variable did not represent end-caps, which are slots located perpendicular to a bank's general orientation. No end-cap units were present in the data set. Small carousels (circular configurations of slot machines) were also considered to be end-units as they too offered easier access by virtue of their design. A categorical variable representing slot signs failed to demonstrate a significant influence on coin-in levels in this study. As many Las Vegas strip properties have over $1 million invested in slot signs, this particular finding is cause for further research.

A related area of research, performance-potential modeling, has produced an abundance of similar findings supporting the notion of increased business volume resulting from retail store locations with superior accessibility and visibility to foot and/or vehicle traffic. Based on the results of slot location-effect studies coupled with the performance-potential findings, Figure 7.10 is offered as the basis of a floor design intended to maximize the number of desirable slot machine locations with regard to visibility, accessibility, and proximity to table games areas.

The major diagonal aisles are designed to accommodate foot traffic to and from anchors located at the corners of the casino floor. Possible anchors would include amenities such as hotel towers, parking garages, restaurants, and retail shopping centers. In essence, it is recommended that the slot floor be designed with respect to the entire property. As visibility and accessibility have been found to produce superior unit-level performance, considerable advantages may result from carefully engineering desirable gaming locations. Many Las Vegas casinos disregard this premise by offering vast expanses of slot machines with little or no apparent motivation for exploration. In markets such as Las Vegas, where slot occupancy is low, it may be more impor-

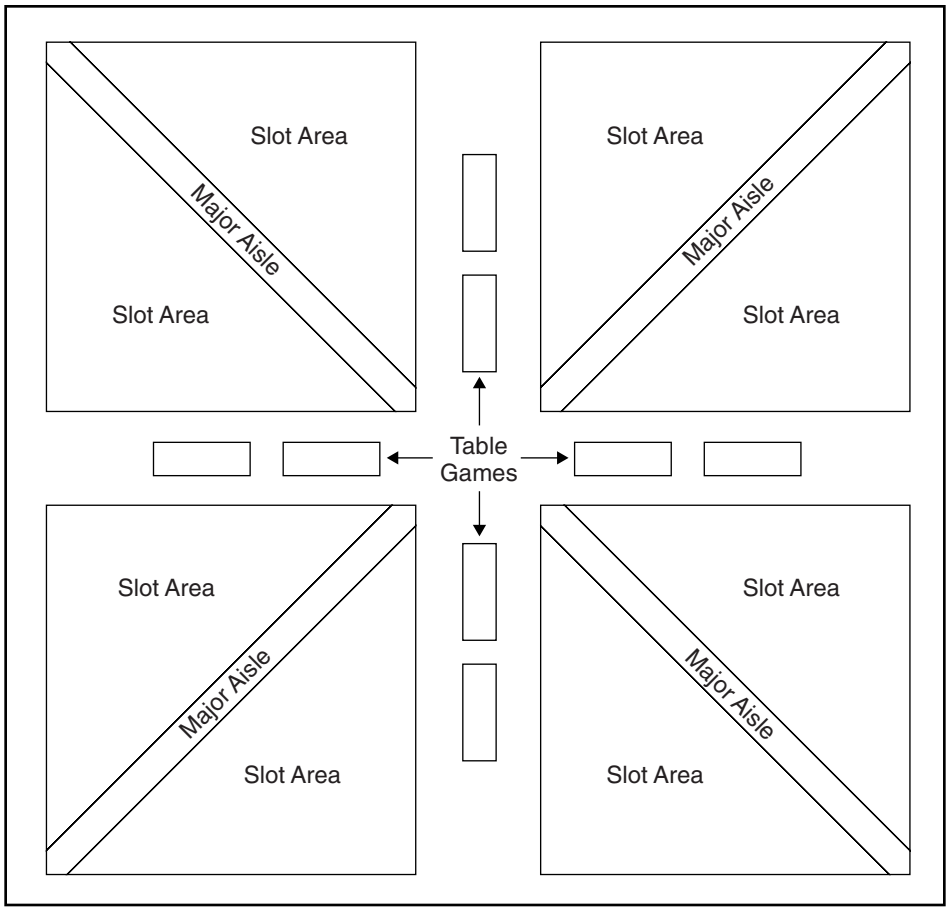

Figure 7.10 Hypothetical Casino Floor Layout

tant to produce a greater number of desirable locations than to simply increase overall capacity.

Although the design depicted in Figure 7.10 may appear regimented or rather uninteresting, it is important to note that adaptations such as winding pathways and generous use of pods[4] on the borders of the slot areas are easily accomplished. Adaptations such as these maintain the basic design, while further improving the visibility and accessibility of interior units. A careful review of the environmental psychology literature would yield many beneficial modifications to improve the ambience and functionality of any slot floor. One particular study includes a limited review of environmental psychology findings that apply to the casino floor layout (Lucas, 2000).

The two location-effect studies were conducted by examining performance data from $1.00 reel slots and $0.25 video poker machines, so the positive pit-border effect has been observed across two different samples. Both data sets were comprised of results from machines located in Las Vegas hotel casino properties. The $1.00 reel data was gathered from a Las Vegas Strip property, while the $0.25 video poker results were collected from a property catering to the Las Vegas locals' market. In order to account for competing sources of causation, the theoretical models tested the effects of the following game characteristics via simultaneous multiple regression analysis: par, standard deviation of the pay table, cabinet style (i.e., slant-top or bar-top), progressive feature, game-within-a-game feature, game tenure on the floor, and maximum coins allowed. Alternatively stated, the effects of these game characteristics on unit-level coin-in were considered before determining the effects associated with the various sections of the slot floor.

THE SLOT FLOOR LAYOUT AND CONSUMER BEHAVIOR

The results of a study conducted at a Las Vegas Strip casino found a construct describing the navigability of the slot floor to produce the greatest impact on consumer satisfaction ratings related to the overall slot environment (i.e., slot servicescape) (Lucas, 2003). Other factors found to influence servicescape satisfaction ratings were seating comfort, overall cleanliness, and interior décor. However, the ability to navigate the slot floor is of particular interest, as it is closely related to the discussion of slot floor layout.

The layout/navigation construct was comprised of scale items addressing consumer perceptions of sightlines, aisle width, signs and directional aids, overall ease of finding destinations, and the number of machines on the floor (i.e., the perceived level of crowding). Survey respondents were asked to rate each of these navigation-related items on a 9-point scale. The overall navigation score produced a positive impact on slot servicescape satisfaction, which in turn produced a positive impact on satisfaction with the overall slot experience. Finally, satisfaction with the overall slot experience was found to be positively correlated with important consumer behavior intentions such as willingness to return and recommend as well as desire to remain in the gaming environment. The results of this study support the notion that satisfaction with navigational aspects of the slot floor layout is part of an important process leading to vital consumer behavior intentions. A similar study conducted across three Reno, Nevada, casinos corroborates this basic result (Wakefield & Blodgett, 1996).

ELEMENTS OF A SUCCESSFUL SLOT SERVICESCAPE

A slot floor servicescape comprises the physical or built components of the environment as well as its ambient conditions. While architectural design and interior décor provide ready examples of the physical or tangible servicescape, ambient conditions are often more abstract, representing intangible background characteristics of an environment. In general, ambient variables are stimuli that affect the five senses, such as air temperature, lighting levels, and cigarette smoke levels. To further clarify the limits of the slot servicescape concept, the attractiveness of cocktail servers could be considered a component of the servicescape, but the promptness or accuracy of the cocktail service would not be considered servicescape components. For more on servicescapes, see Bitner (1992).

As no two casinos are alike, the design components of the ideal slot floor will vary by property. However, this section is intended to summarize the results of empirical research aimed at discovering environmental attributes important to the slot player. In a study conducted at a Las Vegas Strip hotel casino, the floor layout and décor theme were found to positively impact overall atmosphere ratings (Mayer & Johnson, 2003). Researchers found the following attributes of three Reno, Nevada, slot floors to positively influence slot servicescape quality ratings: navigability/accessibility, interior décor/design, and cleanliness. At a second Las Vegas Strip hotel casino, layout navigability, interior décor, cleanliness, seating comfort, and various ambient conditions all positively influenced slot servicescape satisfaction ratings. Ambient conditions were rated via scale items related to cigarette smoke levels, overall lighting levels, air temperature, and sounds of excitement (e.g., clanking sound of coins falling into the metal tray).

In summary, layout navigability and décor ratings have been found to influence player evaluations/responses related to the overall slot floor environment. This finding holds across three different studies comprised of data from five different Nevada casinos. However, any of several other environmental or atmospheric elements could influence slot servicescape satisfaction as well. For example, feelings of safety or the attractiveness of the employees/clientele might produce positive effects. Other possibilities range from ceiling height to environmental odors. Future research will be needed examine these potential effects on slot servicescape satisfaction ratings.

DETERMINING SLOT WIN

To determine how much a given slot machine has won, the following information is needed:

- The slot drop
- The total amount in jackpots

- The total amount in slot fills made
- For progressive slots, the amount of the progressive accrual

With this above information, the formula for slot win is:

Slot win = drop – jackpots – fills – progressive accrual

In addition, the actual hold of the machine can be compared with the theoretical hold by dividing the slot win by the coin-in. Since the casino has use of the amount of the progressive until the jackpot is hit, Nevada's regulations require that gaming taxes be paid pursuant to the following calculations:

Slot win for tax purposes = drop – jackpots – fills

With the use of this method, taxes are paid once the casino has access to the funds. The progressive becomes a jackpot at the time it is hit and, as a result, is deducted from slot win.

THE IMPORTANCE OF HIT FREQUENCY

The manufacturer often provides a catalog of the various machines it produces in order to assist in the selection of machines. This catalog includes graphics of the machine's top and belly glasses. Each machine available has a distinct payback and hit frequency. Typically, each model of machine comes in a variety of paybacks and hit frequencies. The payback and hit frequency of a machine is depicted in the PC sheet included earlier in this chapter. Table 7.2 shows the different paybacks and hit frequencies available for a typical two-coin multiplier.

Strip 3375 is available with a 95.058% maximum coin payback. The 1st coin payback is 94.372%. The machine's hit frequency is 12.777%, and it is a three-reel machine with 64 stops on each reel. The top award at maximum coins-in is $5,000, and the corresponding award is $2,000 at one coin-in. There is only one combination that yields the top award pay-

Table 7.2 Different Machine Paybacks and Hit Frequencies

					Coins in one/two		*Coins in one/two*	
					Top	*JP*	*2nd*	*JP*
Strip	***Max Coin***	***1st Coin***	***Hit Freq.***	***Stops***	***Award***	***Combos***	***Award***	***Combos***
SS3375	95.058	(94.372)	12.777	64ABC	2K/5K	(1)	200/500	(26)
SS3376	92.550	(91.864)	12.390	64ABC	2K/5K	(1)	200/500	(26)
SS3377	91.058	(89.422)	12.337	64ABC	2K/5K	(1)	200/500	(26)

out. The second-highest award at maximum coins-in is $500 and is $200 at one coin-in. If all possible combinations that earn a pay were listed, there would be 26 combinations.

As indicated by Table 7.2, the same model is available in paybacks as low as 91.058% and hit frequencies from 12.337%. Many models are available in over a dozen different payback and hit frequency combinations. All of the machines of a particular model have the same external appearance. From the customer's perspective, the machines all appear to be the same, because the player has no way of knowing the machine's particular configuration. The availability of different paybacks for the same model permits management to provide a mix that will yield the highest casino profit for the space available. The payback of a machine is easy enough to understand, but how the hit frequency affects an individual player lends itself to debate.

When a player plays slots, he will leave the game when one of the following happens:

1. He loses all money available.
2. He wins a specific amount (exit criteria).
3. He must leave because of time constraints.

The player is trying to receive as much play time as possible. Therefore, how do machines with essentially the same payback react to players who leave the machine only when they lose all available funds or they win a specific amount?

If slot players were surveyed, many would be able to identify their favorite machine. These favorite machines are often called "loose" by the player. What makes a machine loose? From management's perspective, a loose machine is one that pays back a significant portion of the amount of coin-in invested. For example, few would argue that a 99.9% payback machine is loose by management's standards, but what if the machine had the following configuration:

Symbols	Reel 1	Reel 2	Reel 3	Reel 4
~	254	254	254	254
7s	1	1	1	1
Total	255	255	255	255

This machine has 4,228,250,625 possibilities. Assume the following payout schedule:

Payout Schedule

7 7 7 7	$4,224,022,374

The jackpot has only one pay combination which is four 7s. When the 7s hit, the machine pays 99.9%. Is this a loose machine? By management's standards it would certainly be considered as such, but only one player will ever call this machine loose. The point is that something the player experiences results in the belief that the machine is loose. A primary factor influencing whether a player believes a machine is loose is the length of play that it affords. To prove this point, ten different machines with essentially the same payback (i.e., 90%) but with hit frequencies varying from a low of 6.7% to a high of 29.6% were selected. Play was then simulated for these machines with different player starting banks and exit criteria. Each machine was a two-coin multiplier.

The simulation was conducted to test the following hypothesis: As the hit frequency of a slot machine increases, pulls per losing player increase, given a fixed bankroll and exit criteria. The following three conditions were examined:

1. Each player started with $100 and quit when $200 ahead or bankrupt.
2. Each player started with $100 and quit when $300 ahead or bankrupt.
3. Each player started with $200 and quit when $400 ahead or bankrupt.

If the theory were correct, the graph in Figure 7.11 would depict an increase in the number of pulls per losing player that corresponds with an increase in hit frequency. However, Figure 7.11 clearly demonstrates a lack of support for this hypothesis. The numbers inside the graph represent the number of players who lost their starting bankroll. In the most favorable outcome, 86.2% of the players lost their starting bankroll (i.e., went bankrupt)! Given the high percentage of losing players, managment must address the process of player satisfaction. Winning players are likely to experience satisfaction, but losing players may expect a certain number of pulls, or time on device, to experience satisfaction.

Further, increasing the payback percentage will not necessarily increase the percentage of winning players. However, machines could be ranked on a "satisfaction index," based on the number of pulls per losing player over some period of time. Management may come to find that game advantages can actually be increased while maintaining the perception of a loose floor. Recent research has found the standard deviation of a game's pay table to be one of the most influential factors in the estimation of coin-in per device. The game's standard deviation is affected by its par, pay-out amounts, and frequency of each possible outcome. If a similar experiment were to be conducted, substituting the game's standard deviation for hit frequency, the result is likely to demonstrate that

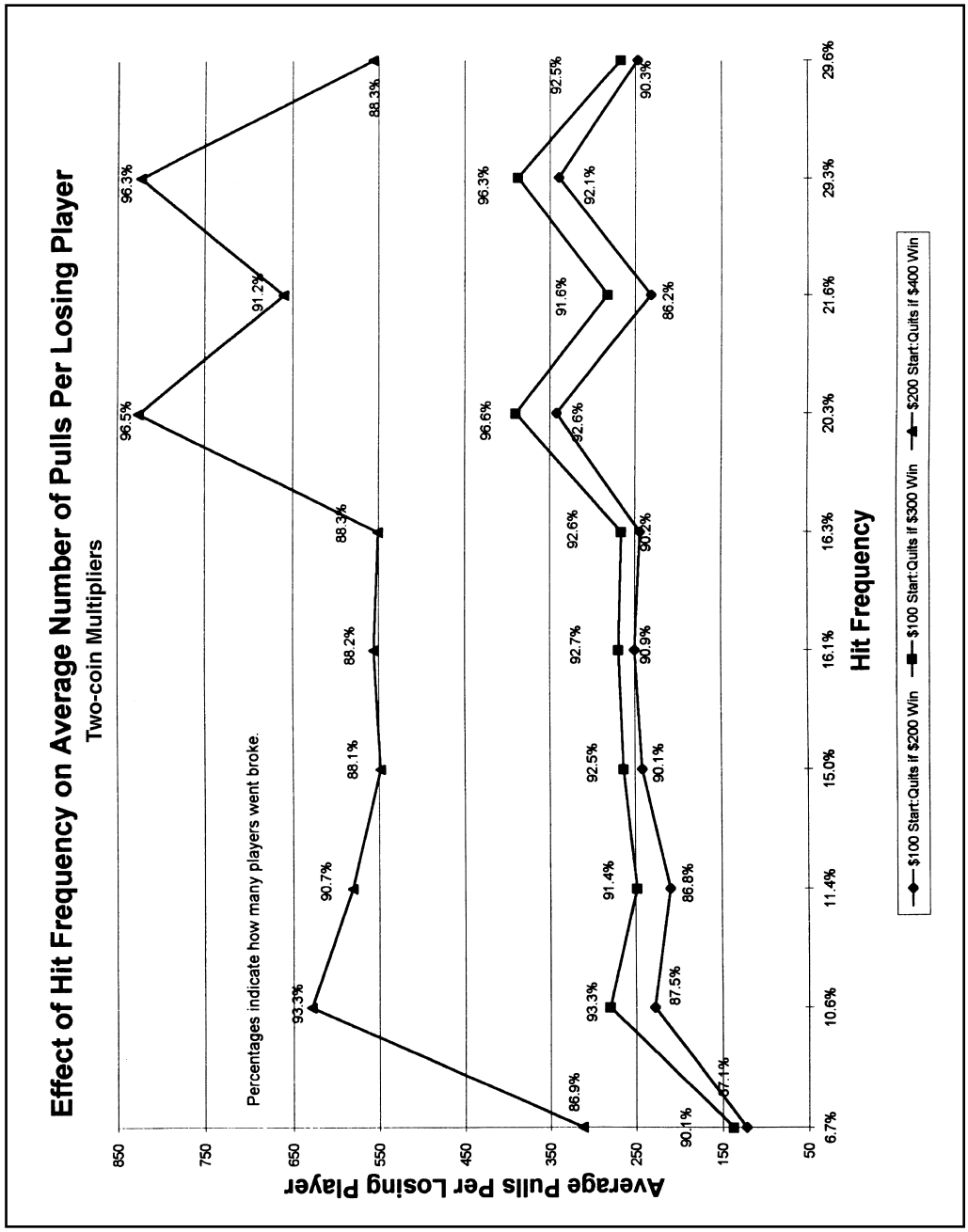

Figure 7.11 Effect of Hit Frequency on Average Number of Pulls per Losing Player

decreases in standard deviation will produce increases in pulls per losing player.

RANDOM OR PSEUDO-RANDOM?

As discussed previously in this chapter, today's slot machine technology allows the symbol to be selected by computer rather than by mechanical means as in the past. With modern stepper slots, motorized reels spin until they stop and display the symbols chosen by the computer. Is this selection by the computer a "random" selection? The answer to this question is no. The selection is not random since the computer must be programmed to choose the symbol to display.

Modern slots have an algorithm called a "random number generator" that selects a number, and the number selected corresponds to a particular symbol. This algorithm is built into the computer's memory. The following is an elementary random number generator:

$$6z \bmod 13$$

where z = 1st the seed and then the last number generated
mod = the remainder of, in this case, $6z$ divided by 13

This random number generator will generate a series of 13 "pseudo-random" numbers before it repeats itself. The generator must first be "seeded." Typically, the seed is a number chosen by the computer's internal clock. In the preceding example, the seed will be the number 1.

$$6 \times 1 \bmod 13 = 13\overline{)6} = 0 \text{ with a remainder of } 6$$

Therefore, the first pseudo-random number selected by this generator is 6. The six then becomes "z" for the selection of the next number.

$$6 \times 6 \bmod 13 = 13\overline{)36} = 2 \text{ with a remainder of } 10$$

If the initial seed is 1, the aforementioned generator will select the following numbers:

1 initial seed

6	10	10
10	8	8
8	9	9
9	2	2
2	12	12
12	7	7
7	3	3
3	5	5
5	4	4
4	11	11
11	6	
1		
6		

The following random number generator (Park & Miller, 1988) will generate a series of 2.147 billion numbers before it repeats itself:

seed = 16807 × (seed mod 127,773) - 2,836 × (seed \ 127,773)
If (seed < 0), then seed = seed + 2,147,483,647

The random number = seed / 2,147,483,647
"\" denotes integer division (i.e., 6 ÷ 4 = 1)

NOTES

1. With a 90% level of confidence.
2. Probability is obtained by dividing # of hits by total hits.
3. Expected Value equals the machine's theoretical win.
4. Slot pods usually consist of three or more machines placed in a triangular (i.e., 3 units), circular (5+ units), or plus-sign (4 units) configuration as opposed to the more space-efficient row or column configurations. Pods are a smaller version of the more traditional carousel configuration.