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Although several aspects of gambling have been thoroughly investigated, little is known about the effect of seasonality on gambling. This study investigated the seasonal patterns in slot-machine usage, based on a unique data set of slot-machine usage from a German gambling centre using time series analysis. Knowledge of seasonal slot-machine usage patterns provides useful insights for researchers, gambling centre managers and legal authorities. Slot-machine gambling activity appears to be highest in November, when poor weather is compounded with lack of entertainment activities and lowest in December, when ample entertainment possibilities may distract people from gambling. The estimated daily and weekly seasonal patterns support the self-control literature, which suggests that self-regulatory failures are more likely when people are more tired; after work, or late in the evening. The high variation in gambling during winter implies that the availability of alternative entertainment activities may have an important influence on slot-machine usage.

Keywords: electronic gaming machines; quantitative; gambling; Europe; empirical

1. Introduction

While several aspects of gambling have been thoroughly investigated, there is very little understanding about the effect of seasonality and public holidays, like Easter, Christmas and New Year, on gambling. Several authors draw attention to this gap in the literature. Laplante and Schaffer (2007, p. 618), for example, point out that 'although anecdotally many people have commented on the seasonality of gambling around annual events, such as winter holidays, the Super Bowl and March Madness (e.g. Lipsyte, 2002; Swartz & Kessler, 2005; Torres, 2006), there have been no peer-reviewed studies of gambling that have specifically addressed the question of seasonality and annual events'. In line with this, Xuan and Shaffer (2009, p. 250) mention as a limitation for their analysis that 'seasonality can impact gambling behaviour associated with sporting events, which is not accounted for in our longitudinal models'.

An indication for seasonal patterns in gambling activities is provided in the meta-analysis of Shaffer, Hall and VanderBilt (1999), revealing a strong positive relationship between the time at which the study was completed and the size of the reported prevalence rates of gambling. Evidence for seasonal patterns in gambling was also provided by Cargill and Eadington (1978) who report seasonality in quarterly gambling revenues.

In this study we consider seasonal patterns in gambling. We focus on one particular gambling activity, that is, slot-machine usage. Based on a unique time series data set of slot-machine usage from a German gambling centre, we estimate a time series model on hourly usage rates to analyse the daily, weekly and monthly patterns in slot-machine

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gambling. Knowledge of the seasonal pattern may provide useful insights for researchers, gambling centre managers, and legal authorities.

For researchers it is interesting to see whether seasonal patterns support prevalent hypotheses and/or theories. For example, the self-control literature suggests that self-regulatory failures are more likely to happen when people are more tired. This implies an increase in gambling activities after work and at the end of the week. Furthermore, it is known that mood disorders are more likely to occur during the dark winter months. This suggests an increase in gambling activities in the period of December to February. Finally, seasonal patterns may indicate whether New Year's good intention or holidays have an effect on gambling activities.

From a managerial point of view, knowledge of the seasonal pattern helps to allocate resources over the day and week. These involve decisions about personnel, supply of snacks and drinks, repair and machine replacement, routing the cash and promotional activities, among others. Finally, authorities may be interested in forecasting quarterly tax revenues from gambling (Cargill & Eadington, 1978) and legal authorities may use the outcomes of the seasonal analysis for decisions about limiting opening hours to reduce gambling.

The outline of this paper is as follows. In Section 2 we provide a brief overview of gambling in Germany. We describe the data and the gambling centre under consideration before going on to estimate the seasonal pattern in the slot-machine time series data in Section 3. In Section 4 we discuss the implications of our results and topics for future research. Finally we draw conclusions in Section 5.

2. Gambling in Germany

The German regulations divide slot machines into two categories: casino-based and street-operation-based machines. Slot-machine centres, such as the one we consider, belong to the street-operation-based category.

Casino slot machines are regulated by the Interstate Gambling Treaty (Glücksspiel-staatsvertrag, 2008), whereas slot machines for street operations are controlled by the Trade and Industry Act (Gewerbeordnung, 2009). Part of this, the Game Regulation (Spielverordnung, 2006), imposes restrictions on street machines in terms of 'stake-per-game' (20 cents), 'winnings-per-game' (€2.00), 'maximum loss-per-hour' (€80.00) and 'long-time-average-loss' (€33.00 per hour).

Street gambling amounts for 32.6% of all gambling activities. The shares of other major gambling activities, such as casino gambling and lotto gambling are 32.3% and 27.3%, respectively (Gassmann, Kaldewei & Lindemann, 2010). The market shares are, €8.125 billion for street gambling, €8.030 billion for casino gambling and €6.789 billion for lotto gambling (Gassmann et al., 2010).

Analyses unanimously indicate that the prevalence of pathological gamblers in Germany is between 0.2 and 0.3%. The estimates about the proportion of problem gamblers in the German society vary more; reported percentages are in the range of 0.29% and 0.56% (Gassmann et al., 2010; Federal Center for Health Education, 2008; Bühringer, Kraus, Sonntag, Pfeiffer-Gerschel & Steiner, 2007). These numbers resemble findings for other European countries (Meyer, Hayer & Griffiths, 2008).

3. Data description

In order to analyse the seasonal patterns in slot-machine usage we rely on a unique data set acquired from a slot-machine centre in Germany. The centre automatically tracks whether and how many of its slot machines are in use at any moment in time. This is translated in an

aggregated hourly usage rate, which is defined as the relative time usage of all machines in the hour under consideration. So, if 24 of 48 machines are in use for the whole hour and 24 machines are used for only half an hour, the usage rate is 75%. Our analysis is based on this aggregated data. The main advantage of this data set is that it captures the actual usage rates and as such it provides an accurate description of how slot-machine gambling varies over time. Unfortunately, we have no hourly data at the individual level, which limits our approach. Individual-level data would allow us to compute variables like duration of stay and the number of visits per week to the centre.

The slot-machine centre is open 24 hours a day. Such extended opening hours are quite unusual in Germany and in Europe; this unique data set allows us to follow slot-machine gambling activities throughout the whole day. Our data set contains hourly slot-machine usage rate statistics from the 1 December 2008, midnight till 01:00 am, to 30 November 2009, 11:00 pm till midnight. More precisely, the data were collected in one hour aggregations and therefore data collection started at the one hour period commencing at midnight on 1 December 2008 and concluded with the hour preceding midnight on the night of 30 November 2009. Hence, the data set contains 8760 data points each representing hourly usage rate. The data set has a few (26) missing observations. To obtain a complete sample, we interpolated the missing values using an approach that accounts for seasonal patterns as well as dynamic time series properties of the usage rate. First, the interpolation we first regressed usage rate on a set of hourly, daily, and monthly dummies to remove seasonality from the series. Next, we used the smoothed values of a stochastic local level time series model on the residuals to impute the missing observations for the deseasonalised series. Finally, we added the estimated seasonal pattern from the regression to these values to obtain estimates for the missing observations in our data set. The values of the observed data were not affected by this approach.

3.1. *Description of the slot-machine centre*

The centre is located in the outskirts of a city with about 75,000 inhabitants. Its service area includes three other cities with 75,000 inhabitants each, which are 3, 9, and 12 miles away from the centre. A larger city of 150,000 citizens is 25 miles away. The centre can easily be reached by car and there is sufficient parking space. The surface of the centre is 576 square metres (689 square yards) excluding the space for corridors, stocks, cloakrooms and the service counter. The centre has 48 video-based multi-gambler slot machines with 20–50 games per machine. The users can choose which game to play. Because of German regulations, the service counter provides only alcohol-free drinks. For playing guests the drinks are usually free. In the direct neighbourhood of the centre there is a restaurant and a petrol station. These are not part of the centre. The gambling centre resembles a typical entertainment centre in Germany with respect to the above-mentioned characteristics.

In December 2008 the company that runs the slot-machine centre conducted a survey to analyse the characteristics of their gamblers and 886 randomly selected centre visitors participated. The outcomes of the survey show that 81% of the visitors are male. The average age of the visitors is 36 years and 77% of the people are employed. Their average net income is €2154.00 per month and 71% of the visitors have low education. It turns out that 83% of customers are smokers, while only 23% of the German population smokes. The gamblers' average household size is 2.6 persons. The average number of visits per month is 11.5 for male and 9.0 for female visitors and the average length of a visit is 2.7 and 3.0 hours, respectively. This indicates that men visit the gambling location more often

but that women stay longer. Similar surveys conducted by other slot-machine centres in Germany show similar figures. Hence, the visitors of our gambling centre are quite representative for gambling centre visitors in Germany. Unfortunately, we have no similar figures to verify this claim for other countries.

3.2. *Seasonal patterns*[1]

We first analyse the general seasonal pattern in slot-machine usage. We regress the usage rate on hourly, daily, monthly, and Christmas, Easter, Pentecost, Ascension Day and New Year dummies.[2] The seasonal dummies take the value 1 for a particular hour, day or month and are zero otherwise. For example, the February dummy is one during every day and every hour in February, but is 0 in the other months. It is impossible to include 24 hourly, 7 weekly, and 12 monthly dummies in the regression. This would lead to multicollinearity problems. If we want to include an intercept in the model, we have to leave out one hourly, one weekly, and one monthly dummy. The choice of the particular hour, day and month is arbitrary. We exclude the first hour (midnight–1.00 am), the Saturday and the November dummies. We choose this reference point as, on average, the usage rate is the highest in the first hours on Saturdays in November. The value of the intercept represents the average usage rate in the first hour on Saturday in November. The values of the seasonal dummies indicate the average difference in gambling activity with respect to slot-machine gambling at this point of time.

The residuals of this regression exhibit serial correlation and hence standard *t*-tests for the significance of the seasonal dummies are not valid. To account for this serial correlation, following the Box–Jenkins (1970) approach, we allow for an autoregressive structure with lags 1, 2, 3 and 23. The Breusch–Godfrey LM test (Breusch, 1978; Godfrey, 1978) for first and 1-up-to-24th order serial correlation in the residual series of the resulting model indicate that the residuals are approximately white noise.[3] Hence, the resulting model can be used to analyse seasonal patterns in slot-machine gambling.

The parameter estimates are displayed in Table 1. We see that there is quite some variation in gambling activities over time. For example, the parameter belonging to the January dummy indicates that, on average, the usage rate in January is 15.16% lower than in November for any given hour and day. Additionally, according to the parameter estimate of the '06:00–07:00 am' dummy, the average usage rate during this hour is 27.68% lower than between midnight and 1.00 am for any given month and day.

Visual illustrations of the seasonal changes of usage rate can be found in Figures 1–3. These figures are derived from the estimation results of the model. Figure 1 shows the hourly variation in gambling activities during a day. The 90% confidence intervals are constructed with respect to the reference point (first hour) and based on White (1980) standard errors to account for possible heteroscedasticity in the residuals of the model. To check whether the usage rate in a particular hour is significantly different from the usage rate in the first hour, one has to check whether the value of the usage rate in the first hour is outside the reported confidence interval.

It is clear from Figure 1 that, apart from the second hour, the usage rate is significantly lower across the day than the usage rate in the first hour. This conclusion is supported by the *F*-test results (F-value $= 35.38$, p-value $= 0.00$), testing the joint absence of the hourly dummies in the model. The graph clearly demonstrates that highest usage rates occur between midnight and 1:00 am, followed by the next hour. After 2:00 am there is a significant drop in the usage rate, which is followed by a continuous decline until 8:00 am.

Table 1. Estimation results.

Variable	Coefficient	SE	*t*-statistics	*p*-values
Intercept	62.32	1.62	38.39	0.00
AR(1)	0.86	0.01	79.41	0.00
AR(2)	−0.18	0.01	−12.71	0.00
AR(3)	0.05	0.01	4.61	0.00
AR(23)	0.04	0.01	5.59	0.00
Holiday dummies				
Christmas	−3.60	4.18	−0.86	0.39
Easter	1.97	2.68	0.73	0.46
New Year	−12.89	3.80	−3.39	0.00
Pentecost	−0.04	3.32	−0.01	0.99
Ascension day	−1.43	3.95	−0.36	0.72
Hourly dummies				
01:00–02:00 am	−0.19	0.51	−0.38	0.70
02:00–03:00 am	−6.48	0.70	−9.32	0.00
03:00–04:00 am	−13.24	0.81	−16.28	0.00
04:00–05:00 am	−20.61	0.85	−24.23	0.00
05:00–06:00 am	−23.76	0.88	−27.02	0.00
06:00–07:00 am	−27.68	0.90	−30.65	0.00
07:00–08:00 am	−28.32	0.93	−30.51	0.00
08:00–09:00 am	−26.68	0.95	−28.13	0.00
09:00–10:00 am	−23.45	0.95	−24.56	0.00
10:00–11:00 am	−20.09	0.97	−20.77	0.00
11:00–12:00 pm	−17.54	0.97	−18.05	0.00
12:00–01:00 pm	−16.21	0.99	−16.45	0.00
01:00–02:00 pm	−13.32	0.99	−13.40	0.00
02:00–03:00 pm	−11.65	1.02	−11.48	0.00
03:00–04:00 pm	−10.22	1.02	−10.04	0.00
04:00–05:00 pm	−9.10	1.00	−9.06	0.00
05:00–06:00 pm	−8.94	0.99	−9.06	0.00
06:00–07:00 pm	−8.54	0.97	−8.83	0.00
07:00–08:00 pm	−6.96	0.94	−7.42	0.00
08:00–09:00 pm	−4.95	0.89	−5.57	0.00
09:00–10:00 pm	−3.10	0.82	−3.78	0.00
10:00–11:00 pm	−2.51	0.71	−3.52	0.00
11:00–00:00 pm	−1.84	0.50	−3.67	0.00
Daily dummies				
Monday	−0.62	0.94	−0.66	0.51
Tuesday	−1.90	0.96	−1.98	0.05
Wednesday	−2.95	0.98	−3.02	0.00
Thursday	−1.14	0.94	−1.22	0.22
Friday	−0.44	0.82	−0.53	0.59
Sunday	−0.59	0.83	−0.72	0.47
Monthly dummies				
December	−14.53	1.79	−8.11	0.00
January	−15.16	1.75	−8.64	0.00
February	−9.44	1.86	−5.08	0.00
March	−11.11	1.81	−6.13	0.00
April	−11.57	1.84	−6.27	0.00
May	−11.36	1.88	−6.04	0.00
June	−10.67	1.85	−5.75	0.00
July	−10.05	1.88	−5.35	0.00
August	−10.12	1.87	−5.43	0.00
September	−6.54	1.96	−3.33	0.00
October	−6.68	1.86	−3.58	0.00

Note: Adjusted $R^2 = 0.74$.

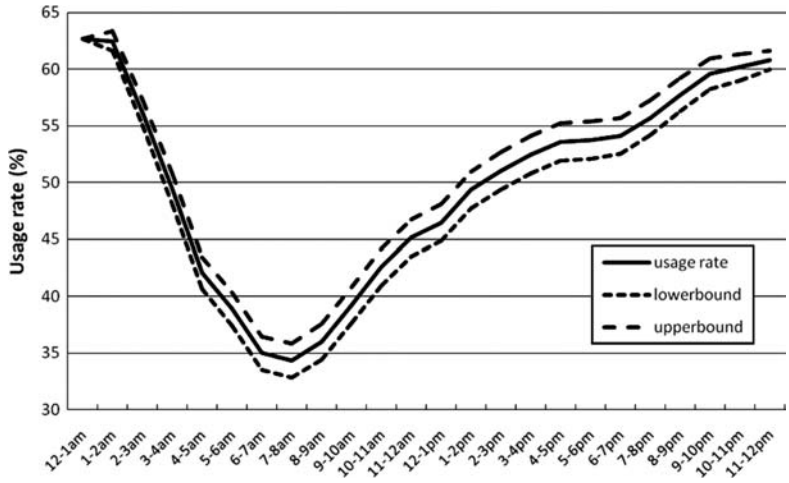

Figure 1. Hourly usage rate evolution with 90% significance intervals.

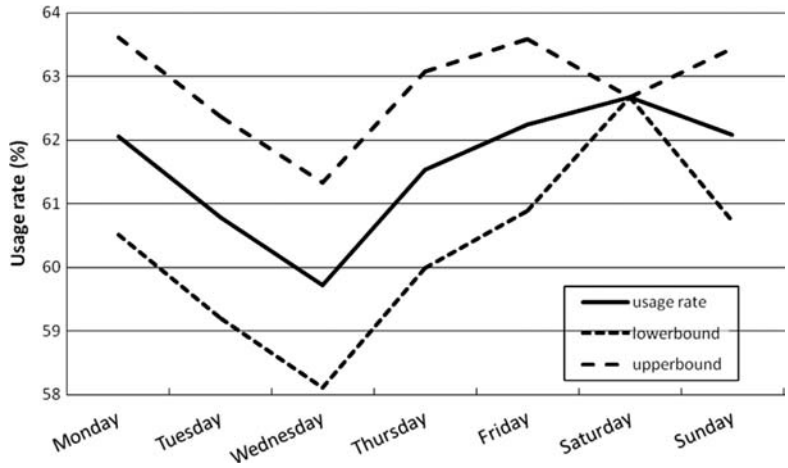

Figure 2. Daily usage rate evolution with 90% significance intervals.

The lowest usage rates, about 20% less than in the peak hours, are observed in the morning between 4:00 and 12:00 am.

Figure 2 illustrates how usage rates fluctuate over the different days of the week. Again the 90% confidence intervals are calculated with respect to the reference point (Saturday). The usage rate for Saturday is not included in the confidence interval of Wednesday and of Tuesday. The F-test for the joint absence of a daily seasonal pattern equals 2.01 (p-value $= 0.06$) indicating slight evidence for significant variation in the daily pattern.

Figure 3 demonstrates the monthly evolution of usage rate of slot machines with confidence intervals constructed in the similar way as before. We see that November is by far the month with the highest usage rate, followed by October and September. Usage rates are markedly lower in December and January than in other months. The joint F-test statistic shows that these differences are significant (F-value $= 8.15$, p-value $= 0.00$).

Figure 3 suggests a trending pattern in the usage rates over the consecutive months. This may imply that the monthly dummies capture an increasing tendency in usage rate

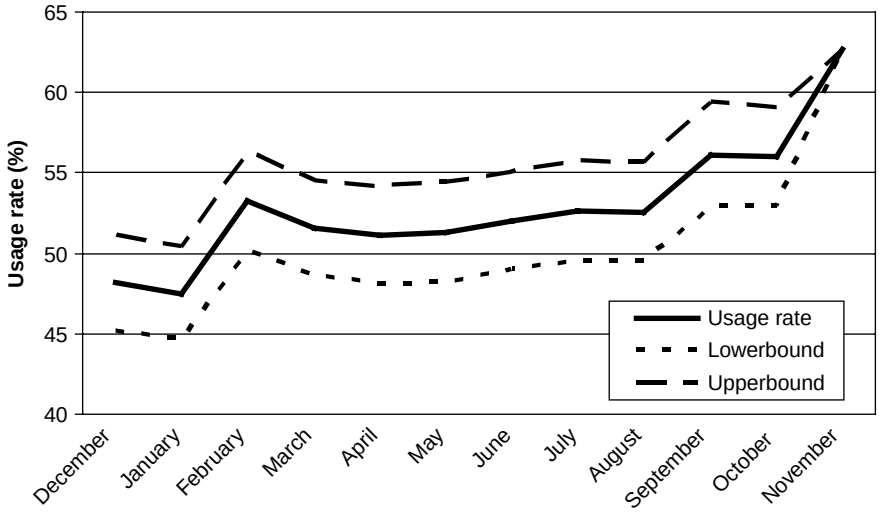

Figure 3. Monthly usage rate evolution with 90% significance intervals.

rather than a seasonal pattern. With a longer sample period, of two years or more, we could easily separate the trend and the seasonal pattern by estimating a model that includes monthly dummies and a monthly deterministic trend variable as well. As we only have one year of observations we cannot distinguish a monthly trend from a monthly pattern this way. However, an upward trend in usage rates is likely to reveal itself up at the weekly level. Therefore, we tested whether there is a trending pattern in the usage rates, by including a deterministic trend at the weekly level in our regression model. This weekly deterministic linear trend variable was generated as follows. It takes the value of one if the observation belongs to the first week of the sample, 2 if the observation belongs to the second week of the sample and so forth. The estimated trend parameter turned out to be negative and not significant. We also included quadratic and third order weekly deterministic trend variables to test for the presence of a non-linear trend. All trend parameters were insignificant, which indicates that there is no evidence for a trend in our sample and that the monthly dummies describe a seasonal pattern.

Finally, we also tested whether holidays have a significant effect on the usage rate. We find only New Year to have a significant impact on (at least this type of) usage rates. During this period usage rate drops by more than 12% as compared with a regular day.

Overall, our results show that gambling activity varies considerably over days, weeks, months. If we compare the estimation results for the different time frequencies, we find that the highest variation in usage rate occurs within a day, followed by monthly fluctuations, and finally, the day of a week seem to matter the least. To investigate whether these seasonal patterns are due to weather conditions, we added (lagged values of) daily temperature and rain fall to the regression model. Unreported results show that these variables do not have a significant effect on usage rate and hence the seasonal patterns cannot be explained by weather conditions.

3.3. *Differences in hourly usage rates across the days of the week*

To analyse whether the seasonal patterns are constant or change over the periods with a lower frequency, we additionally included interaction terms in our model. For easier

interpretation, we did not include all possible interaction terms in one model but rather developed and estimated separate models for the alternative interactions.

We first added the interaction terms between the hourly and daily dummies to the model. Hence, we analysed whether the hourly evolution of usage rate varies across the different days of the week. A joint *F*-test for these interaction terms equals 3.06 with *p*-value 0.00 indicating significant differences in hourly patterns across weeks. Again, we use a graph to summarise and visualise the findings of our model.[4]

From Figure 4 it is clear that the overall shape of the usage rate curve is rather similar over the different days of the week. The peak hours are between 10:00 pm and 2:00 am and afterwards gambling activity declines till about 7:00–10:00 am. We can, however, distinguish two sets of days with a clearly different pattern. The usage rate for Saturdays and Sundays seems to evolve differently from that of other days. During the weekend the slot-machine usage appears to be more equally distributed over the day; the morning dip is lower and the afternoon faces a less steep increase and even, unlike weekdays, an evening dip can be observed between 4:00 and 8:00 pm. This dip can arise from three main sources. First, daily visitors can shift to earlier hours as they are not restricted by having to go to work at the weekend. At the same time, especially for single households, the gambling centre can serve the social needs that are otherwise, at least partly, satisfied at the workplace. In Germany gamblers were found to develop normal social contact with other gamblers; they talk to each other and share their loss and happiness (Ludwig, 2006). In line with this, there has been evidence of significantly higher propensity of singles among gamblers than within the general population. Since Kallick, Suits, Dielman and Hybels (1979) pointed out that singles and those divorced or separated are more likely to gamble than married people, several similar findings have been reported (see, e.g. Petry, Stinson & Grant, 2005). Second, escaping from problems and everyday routine has been demonstrated to be one of the main motivational factors for slot-machine gambling (Fang & Mowen, 2009; Lee, Lee, Bernhard & Yoon, 2006). While this escape appears to take place right after work during weekdays, the weekends themselves provide an escape from the everyday routine, thereby reducing the need to gamble in the afternoon. Finally, most social activities take place in the afternoons during weekends and provide distraction from gambling.

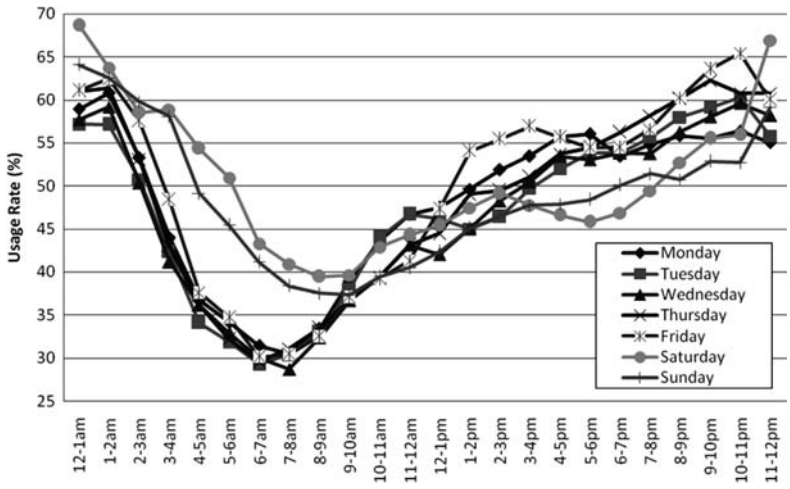

Figure 4. Hourly usage rate evolution across the days of the week.

With respect to the weekdays, the morning hours appear especially to have very similar patterns. In the afternoon more differences occur. For example, on Fridays the afternoon peak in usage rate is higher and takes place about 3 hours earlier than on other weekdays. This may be explained by the shorter working day on Fridays at many companies in Germany.

In the evenings–afternoons of weekdays, usage rates seem to be the highest on Thursdays and Fridays. This can reflect the general pattern of evening activities over the week; people usually go out by the end of the week, knowing that they do not have to save their resources for working. This pattern can also reflect the fatigue hypothesis in the self-control; self-control depends on limited resources (Baumeister, Vohs & Tice, 2007), which are gradually depleted over the week, resulting in an increasing propensity of gambling on Thursdays and Fridays.

3.4. *Differences in hourly usage rates across months*

In the next step, we added interaction terms between the hourly and monthly usage rates to our model. Hence, we now analysed whether the hourly pattern of usage rate varies across the different months of the year. A joint *F*-test for these interaction terms equals 1.24 with *p*-value of 0.01 indicating significantly different hourly patterns across the months. Figure 5 summarises and visualises the findings of this model.

November is clearly the month with the highest usage rates in almost every hour of the day. The overall lower usage rate in December and January is due to lower gambling activity in the morning and afternoon.

3.5. *Differences in weekly patterns across months*

Finally, we added interaction terms between the daily and monthly usage rates. Hence, we analysed whether the daily evolution of usage rate varies across the different months of the year. A joint *F*-test for these interaction terms equals 1.46 with *p*-value of 0.01 pointing towards different daily patterns across months. Figure 6 summarises and visualises the findings of this model.

Gambling does not seem to vary too much across the days in the spring and in summer; however, winter faces quite a lot of variation. November experiences a general rise in the

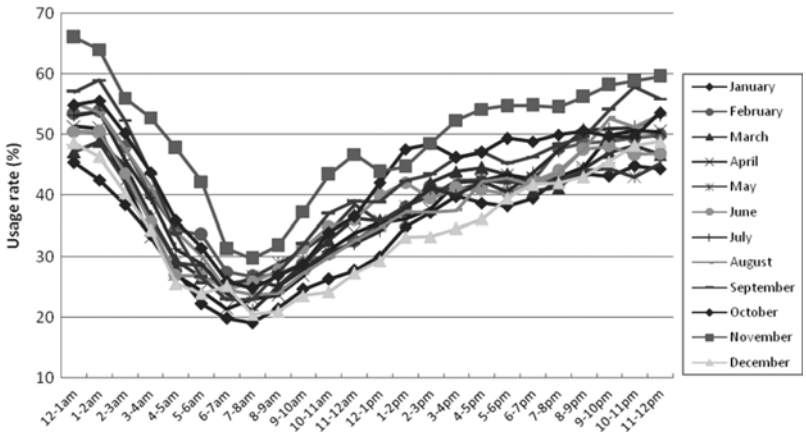

Figure 5. Hourly usage rate evolution across months.

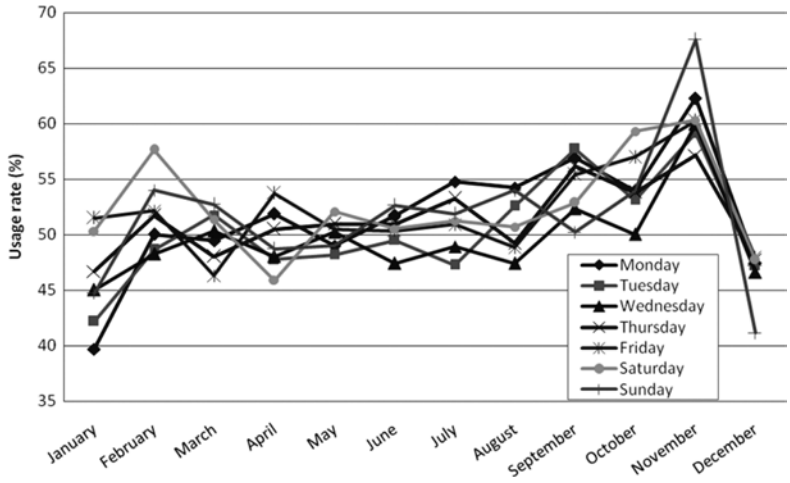

Figure 6. Monthly usage rate evolution across the days of the week.

propensity for slot-machine gambling, while in December and January a significant drop occurs, which is surmounted in February. There is an exceptionally large drop in Sunday visits in December, probably because of the increased opportunities of Sunday entertainment. In December more shops are open on Sundays which diverts gamblers from visiting the slot-machine centre. Additionally, already starting from the beginning of the month, many cities have special Christmas markets. These can satisfy some of the psychological and social motivations for gambling. It is a place where people can socialise (Lee et al., 2006; Neighbors, Lostutter, Cronce & Larimer, 2002), escape from their daily routines and the boredom of modern life (Lee et al., 2006; Jang, Lee, Park & Stokowski, 2000), and fantasise while having fun (Loroz, 2004).

3.6. *Seasonal patterns in expenditures on slot-machine gambling*

Next to the usage rate we also observe total daily expenditures on slot-machine gambling in the centre. Unfortunately, this variable is not available at the hourly level, only at the daily frequency. The total expenditures is highly correlated with the usage rate (correlation = 0.88). Not surprisingly, the seasonal pattern in the daily expenditures is nearly the same as in the usage rates. This means that the seasonal pattern in the daily expenditures is almost completely explained by the seasonal pattern in the usage rates.

There are, however, some minor differences. To explore these, we regressed the expenditure variable on the usage rate variable and investigated the remaining seasonal patterns in the residual series. We see that the expenditures are especially low on Sundays and remarkably high in December and June. This suggests that, given the same level of slot-machine usage, slot-machine gamblers spend less money on gambling on Sundays than on other days of the week and more in December and June than in other months of the year. A possible explanation for these differences is that the gambling centre is visited by different type of gamblers during these periods. For example, on Sunday the centre may attract less regular gamblers who spend less than those who visit at other times. Finally, expenditures are significantly higher during New Year.

4. Implications and future research

Our analysis provides implications for the gambling literature and sets out ideas for new research. In this section we summarise these.

4.1. *Implications*

Although our analysis is conducted at the aggregate level, some of our results are consistent with or provide implications for the gambling and slot-machine literature at the individual level.

Our data provide implicit indications of the fatigue hypothesis of self-control, namely, that self-regulatory failures are more likely to happen when people are more tired, e.g. after work, or late in the evening. The results show that slot-machine usage rates peak between midnight and 1:00 am, almost at the same period of the day that Baumeister and Heatherton (1996, p. 3) derived based on the fatigue hypothesis. Furthermore, we found that during the evenings–afternoons of weekdays, usage rates are the highest on Thursdays and Fridays. This again may reflect that self-control depends on limited resources (Baumeister, Vohs & Tice, 2007), which are gradually exhausted over the week, resulting in an increasing propensity of gambling by Thursday and Friday.

An interesting finding is the high variation in the gambling activity during winter. Existing research shows that mood disorders, which are found to be closely related to gambling (see, e.g. Wohl, Matheson, Young & Anisman, 2008; Kim, Grant, Eckert, Faris & Hartman, 2006; Scherrer et al., 2005), have higher prevalence in winter (see, e.g. Oyane, Bjelland, Pallesen, Holsten & Bjorvatn, 2008; Harmatz et al., 2000; Palinkas, Cravalho & Browner, 1995). This would imply a generally higher slot-machine usage in the winter months. However, we find that although November is the month with the highest usage rates, December and January appear to be the months with the lowest usage rates. So, some other, more important mechanisms must drive fluctuation in gambling activities over time. A possible explanation for the dissimilarity in gambling during the winter may be the difference in the availability of alternative entertainment activities. In November such outside activities are limited and there are no special events or festivities. In December, however, shops are open longer and, already at the beginning of December, many cities have special Christmas markets. These activities can serve the purpose of socialising, entertainment, and escape, thereby diverting people from slot-machine gambling.

The low usage rate of January suggests that willpower and tight budget constraint may also lead to limited gambling activities. In January the New Year's good intentions to reduce gambling may hold for at least some of the gamblers. For a better understanding of the changes in gambling in January, we took a closer look at the usage rate pattern in this month. We found a significant upward trend in the usage rate, even when controlling for hourly and daily variation in the series. We did not find such a trend in any other months. This may confirm one unfortunate characteristic of the New Year's resolutions; that they tend not to hold. Some gamblers return sooner to their standard gambling habits, others somewhat later. An additional explanation for the lower usage rates in January is that, German citizens have to bear the financial consequences of excessive buying of presents for Christmas and their insurance payments (e.g. for their house and/or their car) and several annual bills (e.g. the annual bill for heating and water) are also due in January. In line with this, our detailed analysis shows a significant increase in gambling by the end of the month, when the next salary payment occurs.

4.2. *Limitations and future research*

Although this study showed some interesting patterns in slot-machine gambling, it has several limitations. First, our analysis was based on aggregate data. While we can derive general conclusions about slot-machine gambling, it would be interesting to go beyond these numbers. For example, it would be useful to understand what leads to the increased gambling activity in the afternoons, around midnight and in November. Do these rises occur because in such periods more people gamble or because people stay longer than otherwise? Why is slot-machine usage generally higher in November than in any other months? Is it primarily due to the limited entertainment possibilities in this months or do other factors play a role?

In the slot-machine centre we analyse, most gamblers (about 81%) are males and their behaviour is likely to dominate our results. It would be interesting to understand whether the seasonal patterns of slot-machine usage would be different for women and for slot-machine centres with a higher percentage of female gamblers. In line with this, it would be beneficial to know how the composition of gamblers changes over different points of time. For example, the majority of morning gamblers may be housewives who seek relaxation after having dropped their children to school or kindergarten. Night gamblers may mainly consist of shift workers who relax and unwind before returning home. Additionally, it would be possible to learn about the proportion of problem gamblers in each period.

Understanding the day of a gambler would also provide useful insights for the gambling literature. People may have different gambling activities at different times of the day. Concerning such differences, it would be interesting to investigate whether they (or at least some of them) have a clear pattern in when and how they gamble and what type of gambling they involve with. Would some, for example, make a habit of going to gambling places after work and play online in the evenings? There is very little evidence about how gambling is incorporated in the usual regular daily routines. Insights about the above questions could be collected with the use of additional surveys, tracking studies and diaries.

5. Conclusions

In this paper we studied the seasonal patterns in slot-machine usage rates using a unique time series data set from Germany. Our results showed significant variation in slot-machine gambling over the day, over the week and over the year, where the daily variation is largest and the weekly variation smallest. After accounting for deterministic seasonal patterns, the weather (temperature and rainfall) appears not to have any direct significant influence on gambling intensity. Apart from New Year, which has a significant negative influence on slot-machine usage, there does not seem to be significant difference in slot-machine gambling during public holidays.

Our analysis showed that hourly patterns of slot-machine usage vary across days and months. Gambling activity seems to be more equally distributed over the day during the weekends than during the weekdays. On Saturdays and Sundays the morning dip is less deep since work does not restrict people from going to gamble. In weekend afternoons, people seem to be more engaged in other activities than during weekdays. Slot-machine gambling appears to be by far the highest almost every hour of the day in November as compared to corresponding hours of other months.

Additionally, we found that the time series of slot-machine usage and daily expenditures on slot-machine gambling is highly correlated and that the seasonal pattern in the daily gamble expenditures variable is nearly the same as in the usage rates. The only

differences we find are, given the same level of slot-machine usage, slot-machine gamblers tend to spend less money on Sundays than on other days of the week and more in December and June than in other months of the year.

Notes

1. Seasonal pattern refers to the systematic hourly, daily and monthly variation in usage rates.
2. The holiday dummies run from 6:00 pm of the previous day till 5:00 am after the holiday. The Easter and Pentecost dummies run from Friday evening 6:00 pm till Tuesday morning 6:00 am.
3. A Dickey–Fuller (1979) *t*-test for the usage rate series equals −32.61 and hence the series is stationary.
4. To save space we do not report tables with estimation output. Detailed estimation results can be obtained from the authors upon request.

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