

Research into Influences on Class 4 Gaming Machine Proceeds

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MAKING SENSE OF
THE NUMBERS

Author(s): Mark Cox and Konrad Hurren

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Making sense of the numbers

This report examines the factors affecting spending on Class 4 Gaming machines. In particular, it seeks to explain the apparent upturn in expenditure that started around the end of 2013. Before then, there had been a steady decrease in expenditure that resulted from provisions in the Gambling Act 2003.

The report first analyses expenditure and its possible influences at national level, and then it repeats the analysis at regional level. In both cases, the analysis considers the influence of possible factors individually (univariate analysis). It then considers the influence of possible factors working together (multivariate analysis).

The univariate analysis at national level finds that a number of variables that might be expected to have a positive relationship with expenditure actually have a negative relationship. Expenditure might be expected to increase as GDP, population, employment, earnings, consumer confidence and the number of international visitors increase, but the opposite appears to be true. **However, there does seem to be a positive relationship between expenditure and the number of venues where gaming can happen, and between expenditure and the number of new-generation Stand Alone Progressive Prize (SAPP) machines.** In addition, it was found that expenditure on Class 4 gaming has decreased at the same time as expenditure on other forms of gambling (Lotto, the TAB and Casinos) has increased. Moreover, expenditure on Class 4 Gaming has continued to fall behind expenditure on other forms of gambling, even since the introduction of SAPP machines.

We developed two main types of multivariate model. The first accounted for changes in GMP as a function of past values of GMP and macroeconomic variables; the second extended the first model to include a long term formulation and an explicit treatment of the introduction of SAPP machines.

The first model in our multivariate analysis found no evidence that GMP spend is related to any of the macroeconomic variables (GDP, population, earnings, and the number of international visitors) either individually or jointly. In the second model we formulated we allowed GMP and its relation to macroeconomic variables to respond explicitly to changes in SAPP machines. **This second model also found no evidence that the introduction of SAPP machines changes the relationship of GMP spend to macroeconomic variables.**

The analysis of possible influences on expenditure at regional level was more restricted because there was less regional data available. However, the univariate analysis indicated a positive relationship between expenditure and employment in some regions, and a negative relationship in other regions. There was a more consistent and unexpected negative relationship between expenditure and average earnings, while the relationship between expenditure and the number of venues was positive in all but one region. Consistent with the univariate finding at national level, **SAPPs appear to have lifted expenditure per machine in the majority of regions.**

Regional multivariate analysis has not been attempted due to data availability. It is highly unlikely the macroeconomic variables will have an effect at a regional level, given they did not at a national level. We discuss options for multivariate analysis at a regional level centred on analysing the introduction of SAPPs and modelling GMP spend as a function of its past behaviour.

Given our findings on the inability of macroeconomic variables to explain GMP, we think it would be more fruitful to examine the influences of gamblers' attributes on GMP. Future statistical work, if any, should attempt to more conclusively diagnose the structural shift in GMP spend and ascertain in what period the shift occurred.

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1 Introduction

1.1 Aims and objectives

The principal purpose of this report is to identify the factors that influence changes in gambling expenditure on non-casino electronic gaming machines (EGMs), otherwise known as Gaming Machine Proceeds (GMP). More specifically, the purpose is to identify the factors influencing the changes since 2003 and the recent increases in GMP. An additional purpose is to establish a base for analysis of future trends.

GMP decreased steadily following the introduction of the Gambling Act in 2003, which was introduced (in part) to control the growth of gambling. This decline continued until 2014, but since then there have been year-on-year increases. These recent increases have occurred despite continued decreases in the number of EGMs and venues.

Initial analysis conducted by the Department of Internal Affairs (DIA) hasn't been able to confirm the extent to which these or other factors may have influenced GMP. It was, therefore, determined that the research leading to this report should consider a wider range of possible influences.

1.2 Factors affecting the amount of Class 4 Gaming

The DIA monitors the amount of Class 4 Gaming activity and has explored some of the factors that are likely to influence the activity. These factors include: operator type; other forms of gambling; seasonality; numbers of venues and machines; machine features and technology; population growth; GDP; disposable incomes; employment; visitor numbers and spending; and, region.

In proposing to undertake the research, BERL suggested that it would also be useful to examine the possible effects of regulatory changes, origin of international visitors, and New Zealand consumer confidence.

1.3 Approach and methodology

The various variables (i.e. influences) listed above will have differing strengths, in terms of the extent to which they appear to explain changes in expenditure over time. Some will appear to explain a considerable amount of the changes, while others will appear to explain less. However, what appears to be an explanatory variable might simply reflect an association with the expenditure, rather than being a causal factor. Some variables might be expected to exert a positive influence on expenditure, but actually be shown to have an apparent negative influence. Some variables might also be shown to be insignificant explanatory factors when considered alongside other variables.

It was important, therefore, to adopt an analytical approach that permits the examination of the explanatory strength of the variables, both individually and collectively.

In brief, our methodology entailed:

- 1) Assessing possible influences on GMP individually. This is called univariate analysis.
- 2) Examining the findings of the univariate analysis to decide what sort of multivariate model to fit.
- 3) Testing which of the variables have a statistically significant effect on the expenditure, when analysed alongside other variables. This is called multivariate analysis.

1.4 Structure of this report

Section 2 of this report examines the influences on GMP at national level, while Section 3 examines the influences at regional level. For clarity and ease of exposition, the examination in both these sections starts with univariate analysis and then moves on to multivariate analysis.

Section 4 presents our conclusions and includes some recommendations for future research into what influences GMP.

Some of the multivariate analysis undertaken was highly technical and is likely to be difficult for most readers to comprehend. Accordingly, the text in the main body of the report presents a relatively simple account and leaves the technical detail for the appendix.

2 Modelling GMP at national level

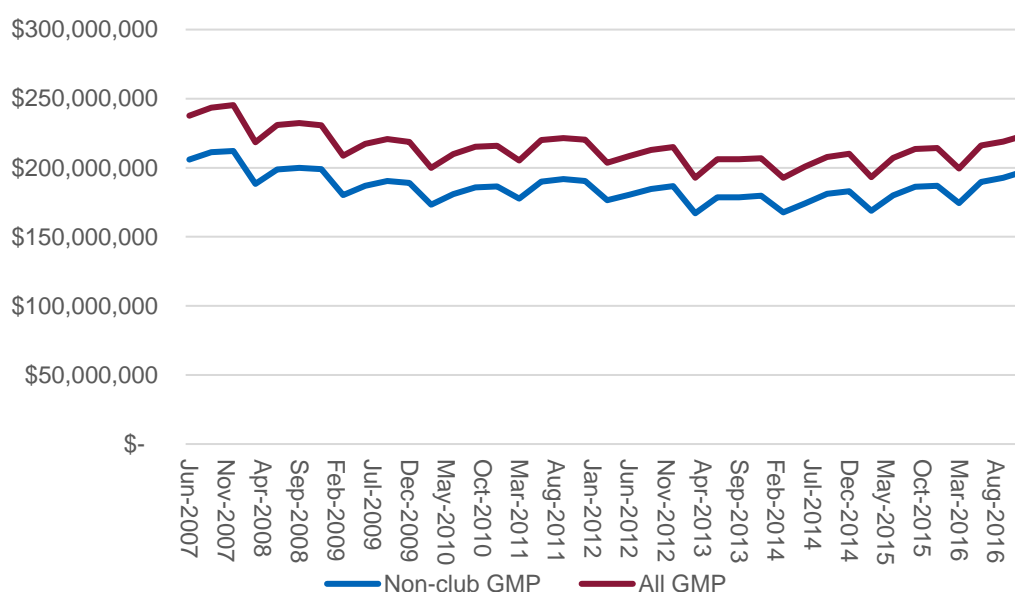
2.1 Trend in GMP at national level

Figure 2-1 shows the trend in GMP in New Zealand between mid-2007 and the end of 2016, and it distinguishes between all GMP and non-club GMP, where the residual is GMP in Chartered clubs, RSAs and Sports clubs.

GMP clearly has a strong seasonal pattern, but the most important feature of the graph is that it shows GMP on a downward trend until around the end of 2013, and then what appears to be the start of an upward trend. However, it might require more time to confirm whether an upward trend has been firmly established.

The seasonal pattern shows that GMP decreases significantly between the fourth quarter of any one year and the first quarter of the following year. It then increases through the second and third quarters to peak again in the fourth quarter. This might be related to the length of the quarters, with the first quarter consisting of 90 days (except in leap years), the second quarter consisting of 91 days, and the third and fourth quarters consisting of 92 days. The low level of GMP in the first quarter might also be associated with the fact that many people are away on holiday at the start of the year.

Figure 2-1 Pattern of GMP over time, New Zealand



2.2 Univariate analysis

In this sub-section, we examine the relationship between GMP and the following possible influences:

- GDP
- Population
- Employment
- Average weekly earnings
- Consumer confidence
- Number of venues where Gaming machines can be played
- Number of international visitors
- Developments in machine technology
- Expenditure on other forms of gambling.

Other things being equal, it might be expected there will be a positive relationship between all but one of these influences and GMP. That is to say, the higher the level of GDP, population, employment etc., the higher the GMP. The exception is expenditure on other forms of gambling, where the likely nature of its relationship with GMP is unclear. We have not included correlation coefficients in the univariate analysis because they can create misleading impressions.

The trend line in Figure 2-2 indicates that, taking mid-2007 to the end of 2016 as a whole, GMP has decreased as GDP has increased. This is contrary to the expectation that, other things being equal, GMP would increase as GDP increased.

Figure 2-2 GMP and GDP, New Zealand, June 2007-December 2016

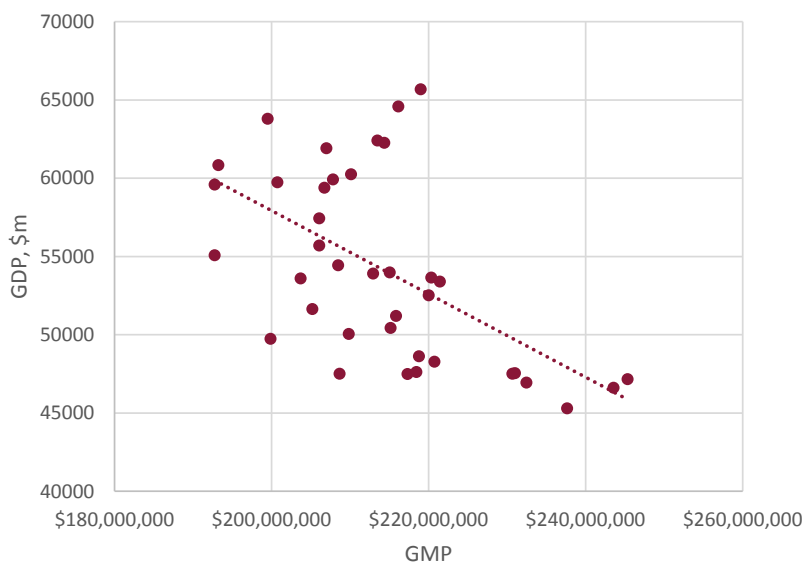


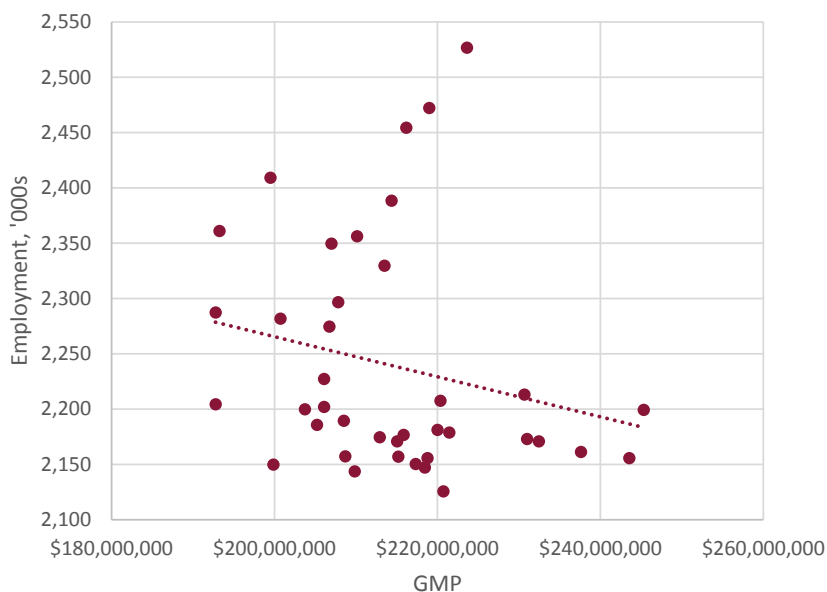
Figure 2-3 paints a similar picture to Figure 2.2. Again contrary to expectation, it indicates that GMP has decreased as the population has increased.

Figure 2-3 GMP and Population, New Zealand, June 2007-December 2016



Similarly, Figure 2-4 shows that GMP has decreased as employment has increased.

Figure 2-4 GMP and Employment, New Zealand, June 2007-December 2016



Likewise, Figure 2-5 indicates that GMP has not increased alongside average weekly earnings.

Figure 2-5 GMP and Average weekly earnings, New Zealand, June 2007-December 2016

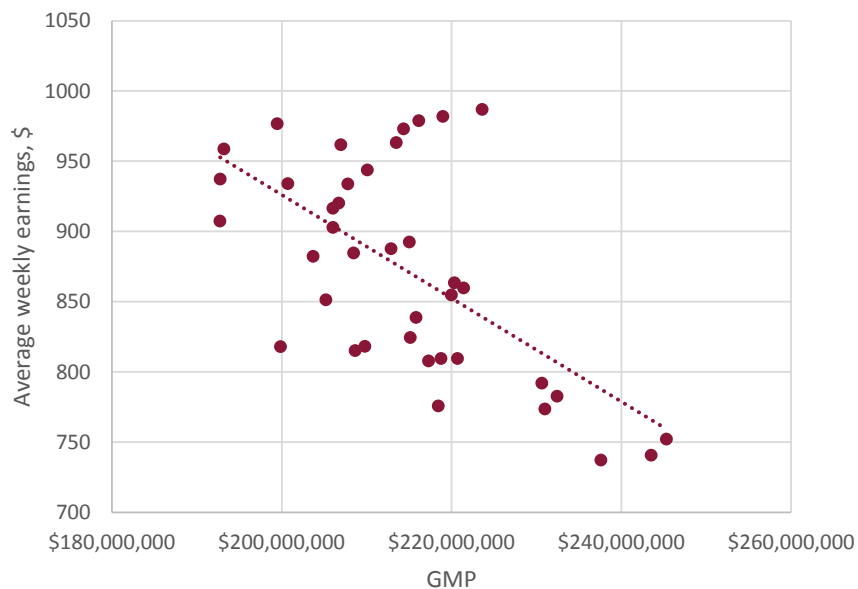


Figure 2-6 indicates that consumers have not been encouraged to spend more on EGMs when their confidence levels have been high.

Figure 2-6 GMP and Consumer confidence, New Zealand, June 2007-December 2016

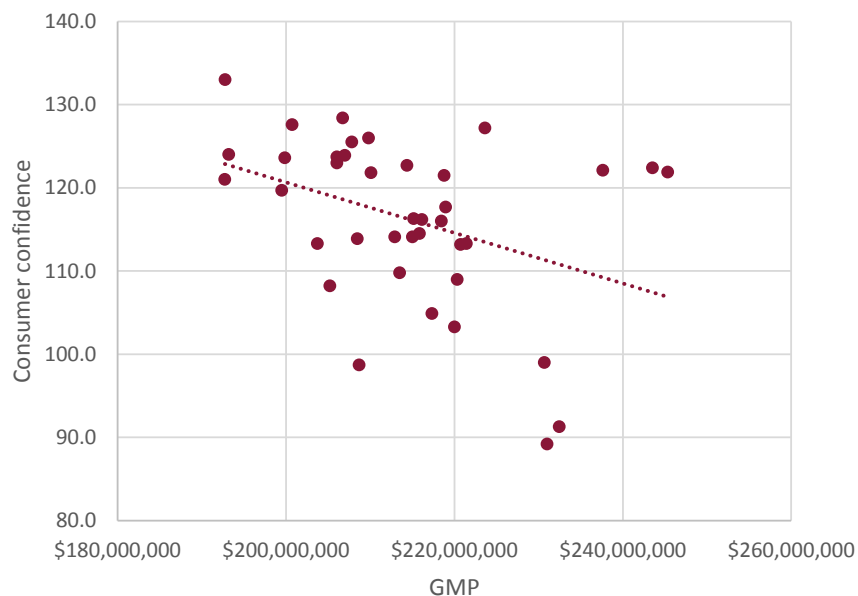


Figure 2-7 is unlike the other graphs in this sub-section, in that it shows a positive relationship between GMP and the number of venues where EGMs can be played. This might imply that, for many people, playing EGMs is a casual activity that is engaged in on an unplanned basis when the opportunity presents itself.

Figure 2-7 GMP and Number of venues, New Zealand, June 2007-December 2016

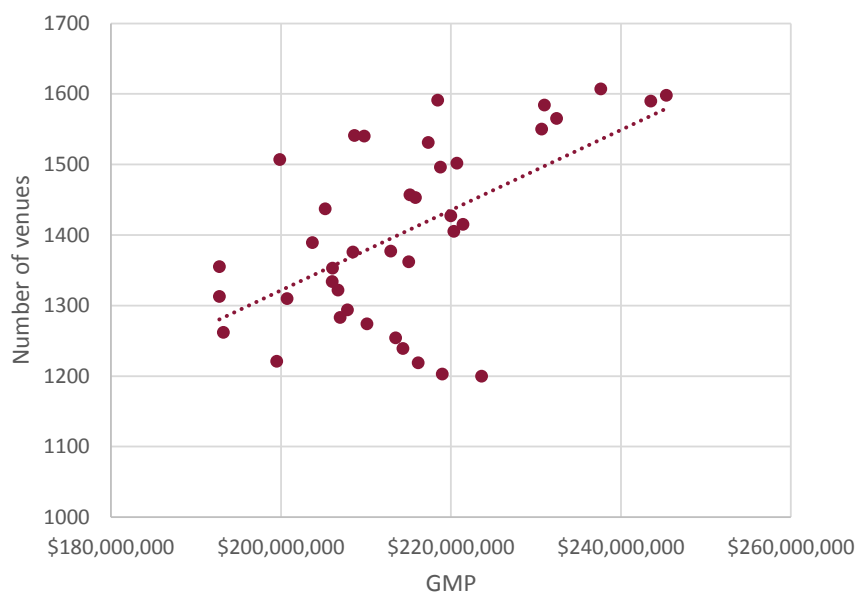


Figure 2-8 indicates that the availability of Stand-alone Progressive Prize (SAPP) machines has a positive effect on the amount of GMP. SAPPs are defined as gaming machines that have games that contribute to incrementally

increasing prizes that can only be won on that gaming machine, and are also capable of winning a linked jackpot which might be won on any one of a number of linked machines at the venue. SAPPs started to be introduced in 2010.

Figure 2-8 GMP and the number of Stand-alone Progressive Prize machines, New Zealand, September 2011- December 2016

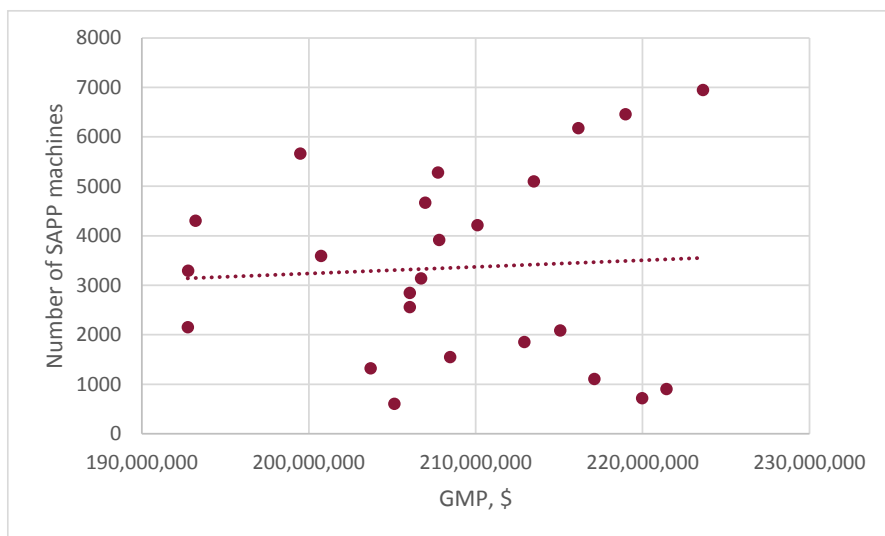


Figure 2-9 implies that SAPP machines are more attractive to the player than non-SAPP machines. In the December 2016 quarter, there were 6,464 SAPP machines and 10,634 non-SAPP gaming machines in use in New Zealand. This includes those that were swapped out for replacement machines, so the total number of gaming machines that were used across the three months is higher than the number of machines operating at any one time.

We also understand that venues that have larger numbers of machines tend to have a greater GMP per machine than venues that have relatively few machines; and it might be the case that the latter venues are more likely to have been retired.

Figure 2-9 GMP per machine per quarter on different types of machine, New Zealand, Sept 2011- Dec 2016

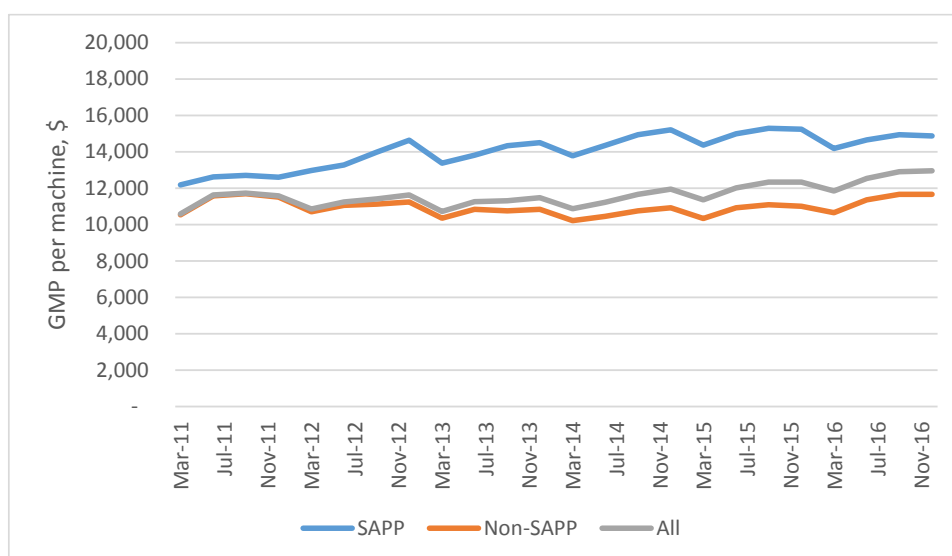


Figure 2-10 suggests that GMP decreases as the number of international visitors to New Zealand increases. However, the fact that the individual observations are widely scattered around the trend line suggests that the relationship is very weak, if there is a true relationship at all.

Figure 2-10 GMP and Number of international visitors, New Zealand, June 2007-December 2016

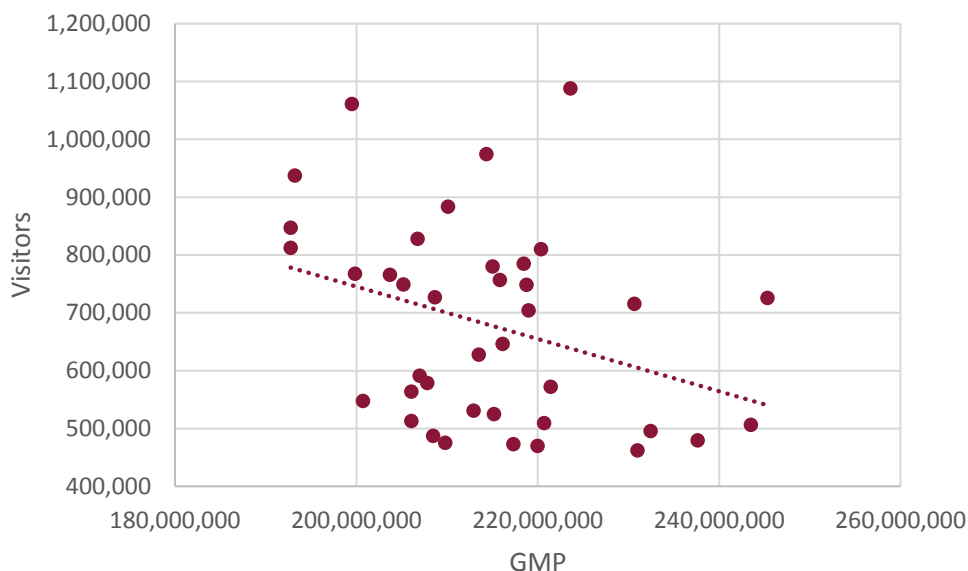


Figure 2-11 compares expenditure on EGMs with expenditure on other forms of gambling, where the other forms combine Lotto, the TAB and Casinos.

Between 2003 and 2005, expenditure on EGMs and other forms of Gambling was similar. However, expenditure on EGMs decreased after 2005, while expenditure on other forms of Gambling increased. The graph confirms that there was a small increase in total expenditure on gaming after 2013, but it also shows that expenditure on other forms of gambling increased more rapidly than expenditure on gaming.

Figure 2-11 Expenditure on Class 4 and other forms of gambling

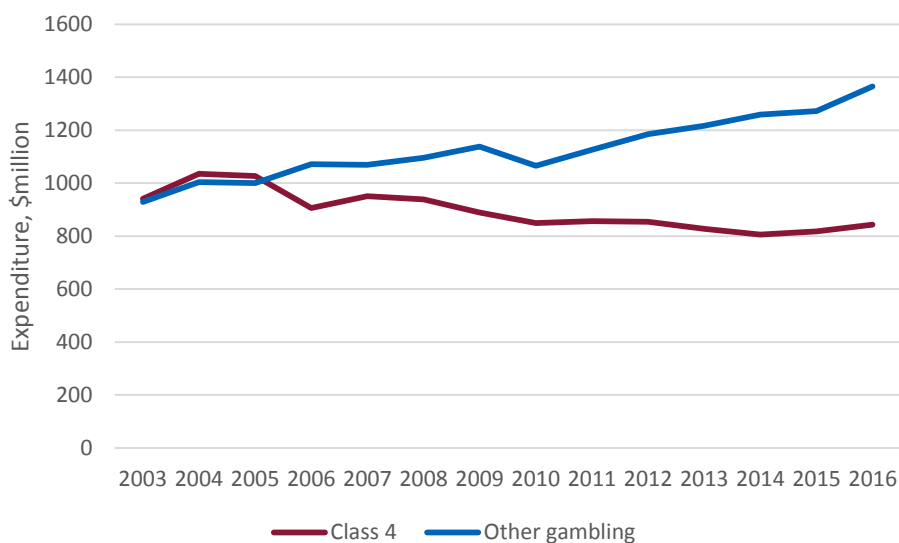
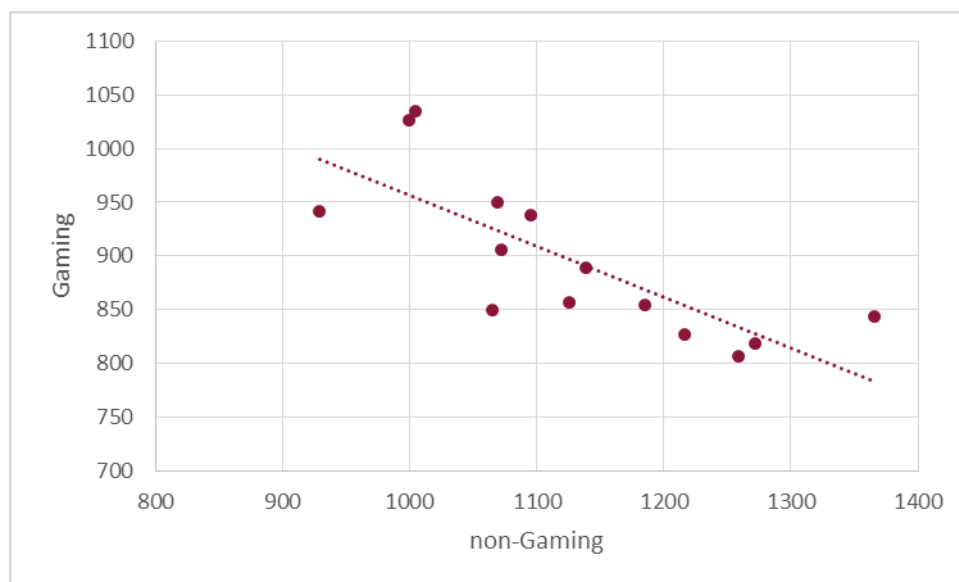


Figure 2-12 plots expenditure on EGMs and expenditure on other forms of Gambling on a scattergram, and it confirms that expenditure on EGMs falls as expenditure on other forms of Gambling increases. Moreover, the fact that the observations are clustered relatively tightly around the trend line implies that the relationship is fairly strong. In other words, expenditure on EGMs and expenditure on other forms of Gambling appear to be good substitutes for one another.

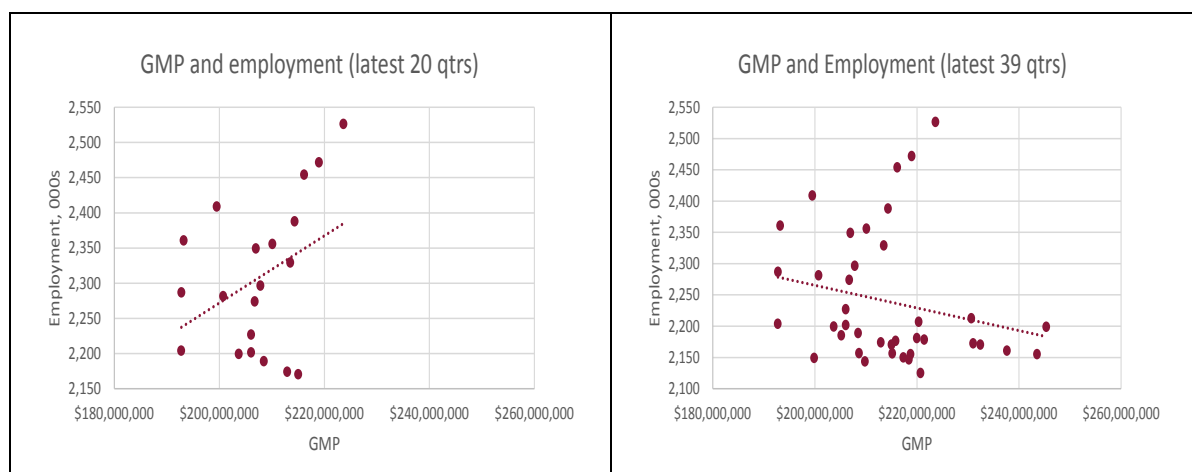
Figure 2-12 GMP and other forms of gambling, New Zealand, 2003-2016



The analysis in this sub-section has shown that the relationship between GMP and most of its possible influences is not what would have been expected. However, the analysis has been relatively simplistic. More sophisticated modelling is undertaken in the next sub-section but, before we proceed, it is worthwhile pointing out that the period over which data is analysed might be as important as the variables that are analysed.

In both parts of Figure 2-13 the relationship between GMP and Employment is illustrated, but the number of observations (i.e. the time points shown as dots in the graph) differs. On the left hand side, the relationship between GMP and employment over 20 quarters is plotted, and there appears to be a positive relationship. However, on the right hand side (which is a replica of Figure 2-4), the relationship appears to be negative. This again, points to the need for more sophisticated analysis to establish if possible influences are true influences or not.

Figure 2-13 GMP and Employment over different timescales



2.3 Multivariate analysis

The multivariate analysis we undertook was a combination of two different time-series modelling techniques. The first model we considered was a system of equations which attempted to explain GMP spend by considering: past values of GMP, earnings or income of people, venue numbers, GDP, population, and tourism visitor numbers. The second model extends this model to consider further past values of the variables of interest, their inter-relatedness as well as the effect of the introduction of SAPP machines.

Although the univariate analysis strongly suggested that economic variables do little to explain the amount of GMP, we included them in the multivariate modelling nonetheless. This is because it is possible that a variable that does not appear to explain GMP by itself could conceivably explain GMP when considered alongside other variables.

2.3.1 General model

In general we might think of GMP spend at any single point in time as being the outcome of different individual influences. We hypothesised that these could include: earnings or income of people, venue numbers, GDP, population, and tourism visitor numbers. We want to acknowledge here that these variables are macroeconomic in nature, they are aggregations of economic events. We use these variables as proxies for the variables we believe might be behind changes in GMP spend.

This model, then, would take the form:

$$Y = a + bX_1 + cX_2 \dots + \epsilon$$

where Y = GMP spend.

The remaining terms need some explanation:

- a is a term used to capture the base amount of GMP spend, absent all other effects.
- Each of X_1, X_2, \dots, X_n are the variables of interest (earnings or income of people, venue numbers, GDP, population, and tourism visitor numbers) at any one point in time.
- ϵ is a *residual* and captures any remaining variation in GMP spend that is not related to the variables or the a term.
- Finally; b, c, ..., g are *coefficients*. They tell us how much GMP spend changes if we increase, say, GDP by one dollar.

Our analysis has refined this general model to consider GMP spend *over time*. Therefore, the model as presented is not quite sufficient. The following model is very similar in structure and logic to the one presented above and details how GMP spend is *realised* at any point in time.¹

$$\text{GMP}_t = a * \text{GMPT}_{-1} + b * \text{GMPT}_{-2} + c * \text{earnings}_{t-1} + d * \text{earnings}_{t-2} + e * \text{Venues}_{t-1} + f * \text{Venues}_{t-2} + g * \text{Visitors}_{t-1} + h * \text{Visitors}_{t-2} + i * \text{GDP}_{t-1} + j * \text{GDP}_{t-2} + z_t$$

As before, the terms a, ..., j are coefficients which tells us by how much GMP in any period t will change in response to a change by one unit in any single variable. The subscripts t, t-1 and t-2 in the equation refer to time periods. The equation tells us that GMP spend in the current period (t) is equal to some linear (straight line) combination of spend in previous periods (t-1, t-2). Finally the last term, z_t is of critical importance in this analysis. It is much more important than ϵ from before. It captures not only how GMP in the current period behaves, but also how past values of GMP behave, over time.

¹ The symbol * simply means “multiplied by” i.e. the coefficient a “multiplied by” the variable GMP

We hypothesise that GMP may be a function of itself, i.e. it may change over time in some predictable way. This effect is captured by a, b and z_t in the above model. Earnings are thought to be a predictor of GDP, we know that different goods behave differently when income increases. Our univariate analysis indicated that gaming machines may be an inferior good, compared to other forms of gambling. Therefore as income increases GMP spend should decrease. This effect is captured by c and d. The number of venues is thought to increase GMP spend as if people observe there are more venues available to gamble they are more likely to go gambling more often. This effect is captured by e and f. Similarly, visitor numbers may help explain GMP spend as tourists may be a group that spends a disproportionate amount on gambling. Each tourist comes to New Zealand with a budget and that may include a large gambling component. This effect is captured by g and h. Finally, we hypothesise that as the economy at large grows and people become wealthier then gambling activities should change. We have no prior belief about the direction of this change, as it is just as likely to be negative as positive. This effect is captured by i and j.

Before concerning ourselves with the size of the effects a,..., j we need to make sure each of the variables considered as well as the z_t are *well behaved*. What we are looking for are variables that “hover around” a certain average value. If a variable is “exploding” away over time we must transform it mathematically to force it to “hover around” a value over time.

Below we present the simplified results of a series of diagnostic tests, details are contained in the appendix.

2.3.2 How each variable behaves in time

The first step we considered was a trend over time in each variable and the effects of seasonality. We found that all variables had a linear (straight line) trend over time and that earnings visitor numbers and GMP were all highly correlated with what particular season it was. *Season* here refers to what quarter of the year the data comes from (for example the first season is considered to be January, February and March). It was decided at this point that we should *correct* for the effects of seasonality and trend in each variable. From this model we extracted the *corrected data*.

The next step we considered was the behaviour of each of our variables over time. We ran a diagnostic test on whether the variables “hover around” a certain value or not, the results are displayed in shown in the Appendix. The results of this test indicate that the correction for trend, seasonality and any transformations we performed have resulted in variables that are *well behaved*. Except for the population variable, which we subsequently dropped from the analysis.²

We had to transform GMP spend by taking a natural log. All other variables were *differenced*. Meaning we subtracted the observation at one time period before from each observation. This is considered best practise in getting *well behaved* variables.

After these transformations the final model took the form:

$$\ln(GMP)_t = a * \ln(GMP)_{t-1} + b * \ln(GMP)_{t-2} + c * \Delta earnings_{t-1} + d * \Delta earnings_{t-2} + e * \Delta Venues_{t-1} + f * \Delta Venues_{t-2} + g * \Delta Visitors_{t-1} + h * \Delta Visitors_{t-2} + i * \Delta GDP_{t-1} + j * \Delta GDP_{t-2} + z_t$$

This model is identical to that presented above but details the transformations done to each variable.

ln is a natural logarithm function, and Δ is a symbol meaning “difference”. i.e. Δ earnings in period t is equal to earnings in period t minus earnings in the prior period.

² This is a common practise, if you cannot transform your variable to be *well behaved* retaining it will invalidate your resulting analysis.

This equation states that GMP spend in any period (t) is a function of the last two periods of GMP spend, change in venue numbers, change in visitors and change in GDP.

Before concerning ourselves with the size or direction of a, \dots, j we must be sure that their effect is “real” i.e. is it *statistically significant* or simply due to randomness.

We followed best econometric practice in fitting the above model via the appropriate methodology. The resulting tests indicated that none of the variables was *individually* statistically significant. And, the variables *together* were not statistically significant. From this, we can conclude that GMP spend is not a function of earnings, venue numbers, visitor numbers, or GDP.

Further, we tested whether the macroeconomic variables can be said to “Granger-cause” GMP spend. This is not quite a causal relationship, loosely it can be thought of as “probably cause”.³ The result of this test was inconclusive, we cannot say if the macroeconomic variables together *Granger-cause* GMP spend. In plain language, based on the form of model outlined above, we are not satisfied that any of the variables considered adequately accounted for the changes observed in GMP.

GMP spend is the aggregation of thousands of gamblers around the country individually deciding how much money to spend on their gambling activity. It is, at heart, an individual choice. The other variables so far considered have been aggregations of every person’s earnings, number of venues, visitor numbers and GDP. They are, by nature, Macro level variables.

To get an idea of what “causes” GMP spend to increase future work should consider individual level data (micro level). I.e. we may want to consider the earnings of the gamblers, number of children, demographic variables, and possibly even variables describing other behaviours like alcoholism, prison sentences, employment status, and highest level of education *inter alia*. A good starting platform for future research would be a literature review of the factors that help explain gambling.

It is important to note here that this model, in making each variable *well behaved*, cannot take account of the shift in GMP spend from a strong negative trend to a slight “uptick” near 2014. This shift is the subject of the next part of our analysis.

2.3.3 Making sense of the shift in GMP

Do the variables “move together”?

Our analysis above on the macroeconomic “causes” of GMP spend was inconclusive, so we decided to test the untransformed variables (the ones that are not *well behaved*). The test we conducted on these variables is one of *cointegration*. Loosely, this means that the variables “move together” through time because some underlying mechanism drives them both. This theory is widely used in macroeconomics to explain the movements of the price level and other macroeconomic variables.

With regard to GMP spend we might imagine that each of the macroeconomic variables moves over time and affects GMP spend in ways not captured by the previous model.

In our univariate analysis we showed simple linear (straight line) relationships between the variables. The following tests for *cointegration* will let us know whether those straight lines paint a reasonable picture of reality. To test this theory we fit 5 models that took the familiar form $Y = a + bX_1 + cX_2 \dots + \epsilon$. We are completely unconcerned here with a, b and c ; rather we are very interested in ϵ .

³ Careful attention to the fallacy of *post hoc ergo propter hoc* is important. For further detail on Granger causality see Granger, C. W. J. 1969 *Investigating causal relations by econometric models and cross-spectral methods*. *Econometrica* 37, 424-438

We conducted various statistical tests on the ϵ that we recovered from these equations, details are provided in the appendix. For all variables, except visitor numbers, we found that there is no evidence of a *cointegrating relationship* between that variable and all the other variables. I.e we cannot say if they “move together” through time.

Visitor numbers was an outlier in this test and we further considered the behaviour of each variable and found that in this particular test specification visitor numbers was not *well behaved* so any results from statistical tests are invalid.

Including SAPPS

Up until this point our multivariate analysis has not included SAPP machines. These machines elicit a different sort of behaviour from gamblers by showing standalone prizes on each machine. We believe this may influence gambling by making it seem more likely a jackpot will be awarded for playing a certain machine.

Our univariate analysis indicates that the introduction of SAPP machines may have caused a sufficient shift in gambling behaviour to undo the downward trend in GMP in periods before 2011 (when SAPPs were introduced).

In the multivariate analysis, rather than explicitly try to find the size and direction of the SAPP effect, we are instead looking deeply into the movement of the relationship between variables to determine whether the introduction of SAPPs has resulted in a shift of behaviour.

The model we consider takes the form of that found in Juselius (1992).⁴ We forgo explicitly providing our model equation as it is unintuitive and unlikely to add value to the analysis. Our analysis here is unconcerned with the individual coefficients rather it considers the relationships between each variable.

Following the procedure found in Juselius, we found that, even when SAPPs are included in the model, no evidence is found of a “long run” relationship between the GMP spend and the macroeconomic variables. **What this indicates is that there is unlikely to be a relationship between macroeconomic variables and GMP spend, even when explicitly controlling for new gaming technology.**

2.3.4 Conclusions from the multivariate analysis

The results from our multivariate analysis can be summarised as follows:

1. There is no evidence that past values of GMP spend, GDP, earnings, visitor numbers, or venue numbers have an individual or join effect on GMP spend.
2. There is no evidence that the variables GDP, earnings, visitor numbers, or venue numbers “Granger-cause” GMP spend.
3. There is no evidence that the variables and GMP spend *move together* through time.
4. There is no evidence that introducing SAPP machines changed the structure of the relationship between GMP spend and macroeconomic variables.

As indicated above, future work needs to focus on micro level data from individual gamblers instead of macro level economic data. Should this be unavailable future work could consider modelling just the GMP series as a function of itself in prior periods and attempt to divine in what period the behavioural shift from the SAPP machines took effect.

If, at the national level, this analysis shows a structural shift from the introduction of SAPPs a regional analysis could be undertaken.

⁴ Juselius, K. (1992). Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK. *Journal of econometrics*, 53(1-3), 211-244.

For now, our strongest conclusion and platform for policy discussion is the evidence found in the univariate analysis; that SAPP machines change the behaviour of gamblers sufficiently to increase the GMP per machine.

3 Modelling GMP at regional level

This section is similar in structure to the previous section. It starts by examining region-by-region trends in GMP over time. It then presents some regional univariate analysis, and then it introduces a multivariate regional model.

It should be noted, however, that there are fewer potential explanatory variables at regional level than there are at national level. A number of the variables for which data is collected on a quarterly basis at national level either have data collected only annually at regional level, or they don't have regional data collected at all.

3.1 Regional trends in GMP

Figure 3-1 plots the trend in GMP in the various regions in the North Island, while Figure 3-2 plots the trends in the South Island regions. The national trend is also shown for comparison.

Figure 3-1 reveals a pronounced seasonal pattern in GMP in most of the regions, although the seasonality appears to be very strong in Auckland and less obvious in Gisborne.

Taking June 2007 to December 2016 as a whole, there is a downward trend in all the regions. However, in Auckland, the Bay of Plenty, Hawke's Bay, Manawatu-Whanganui, Northland and the Waikato, the trend appears to be upwards from around 2013.

There does not appear to be any real sign of a late upward trend in Gisborne, Taranaki and Wellington. And the pattern in Gisborne seems considerably more erratic than in the other regions.

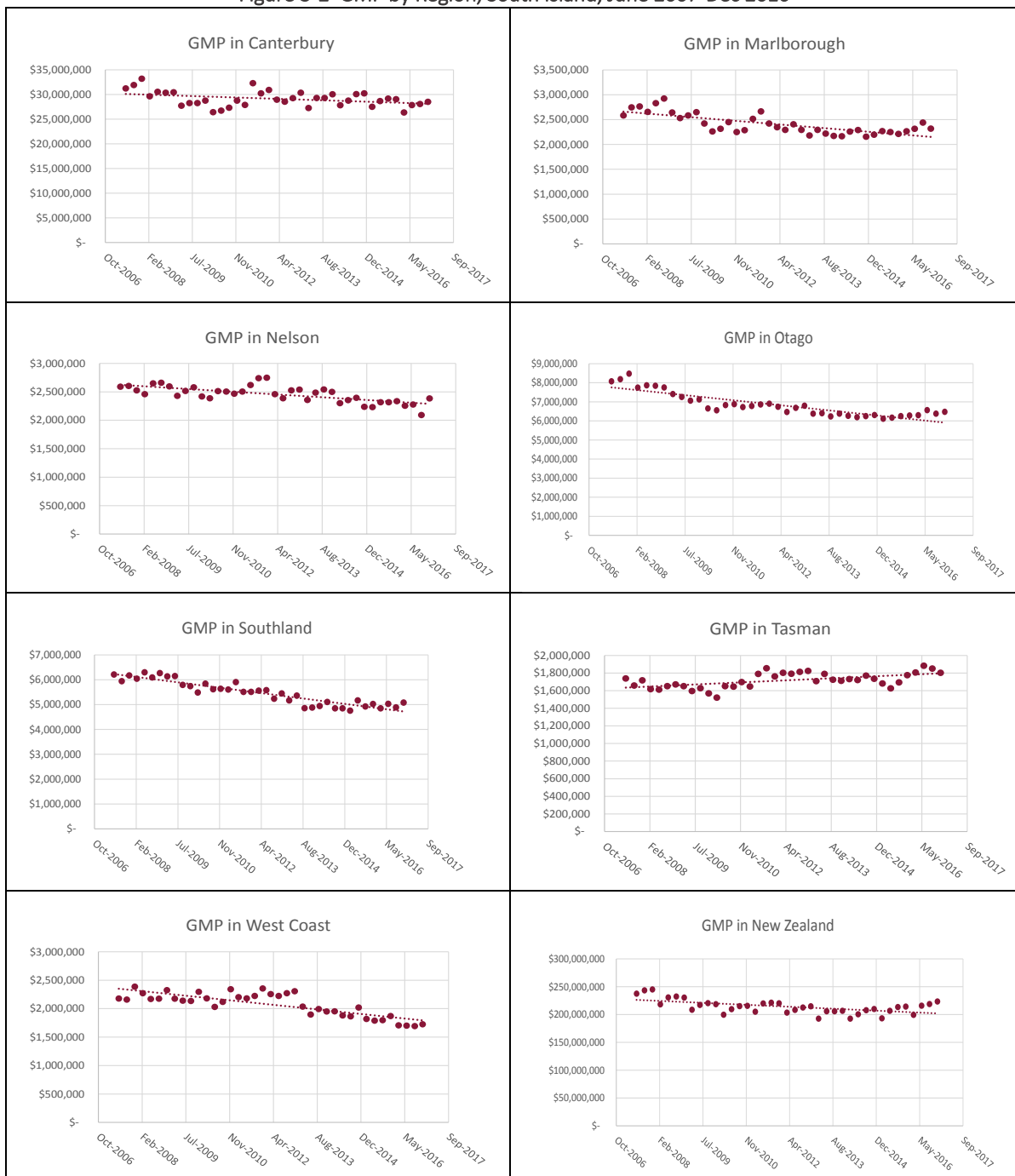
Figure 3-2 suggests that, with the exception of Canterbury, there is a less pronounced seasonal pattern in GMP than in most of the North Island regions. But it shows that there is a downward trend in GMP, with the notable exception of Tasman.

Perhaps most interestingly, however, none of the South Island regions appear to exhibit the same change in trend in GMP after 2013 that most of the North Island regions do.

Figure 3-1 GMP by region, North Island, June 2007-Dec 2016



Figure 3-2 GMP by Region, South Island, June 2007-Dec 2016



3.2 Univariate analysis

As was noted in section 2, other things being equal, it might be expected that expenditure on gaming would increase as employment increases. However, Figure 3-3 shows that this is not necessarily the case. The relationship appears to be positive in four of the North Island regions, negative in three of the regions and unclear in one other region (Auckland).

Figure 3-3 GMP and employment, by North Island region, June 2007 – December 2016

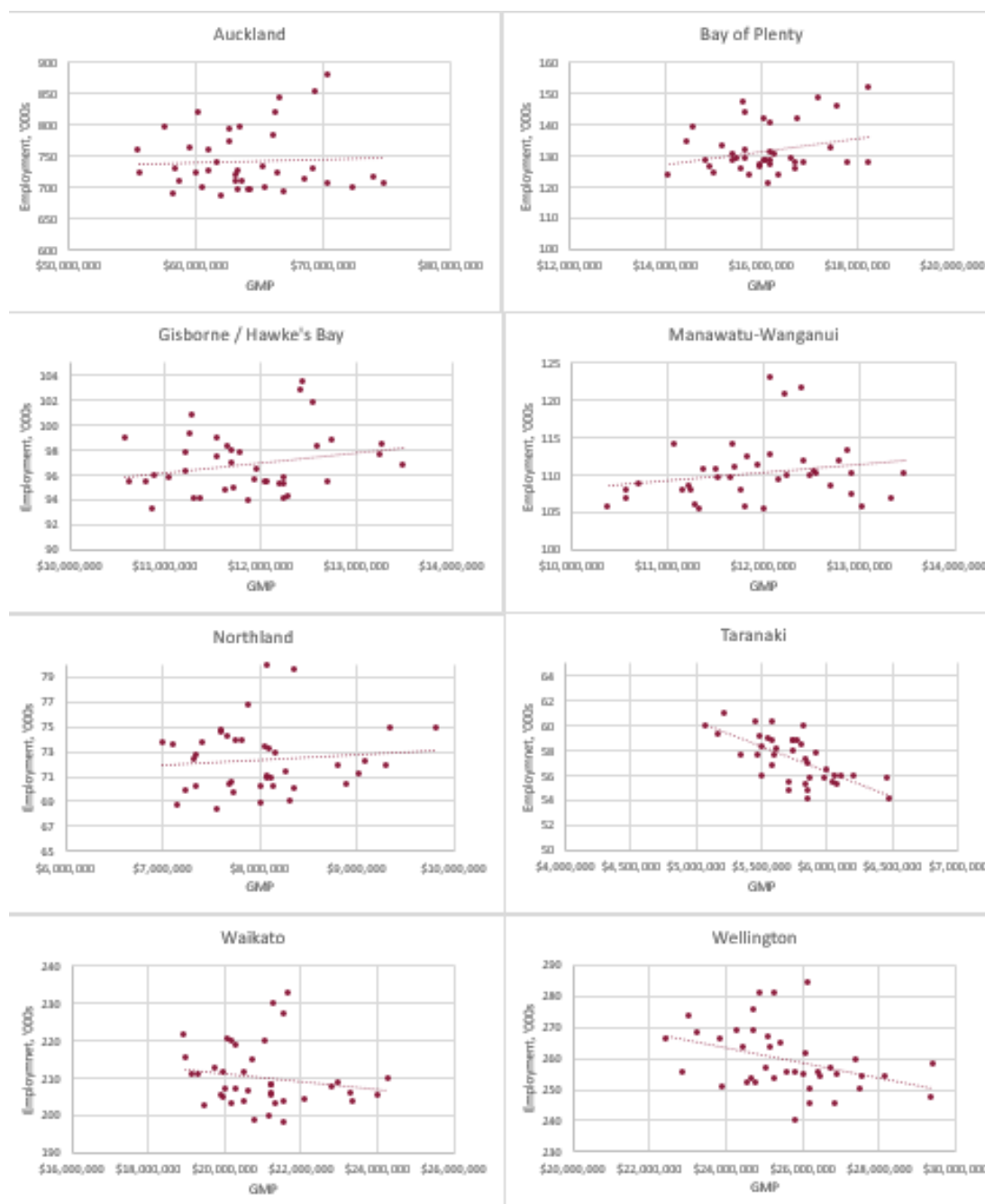
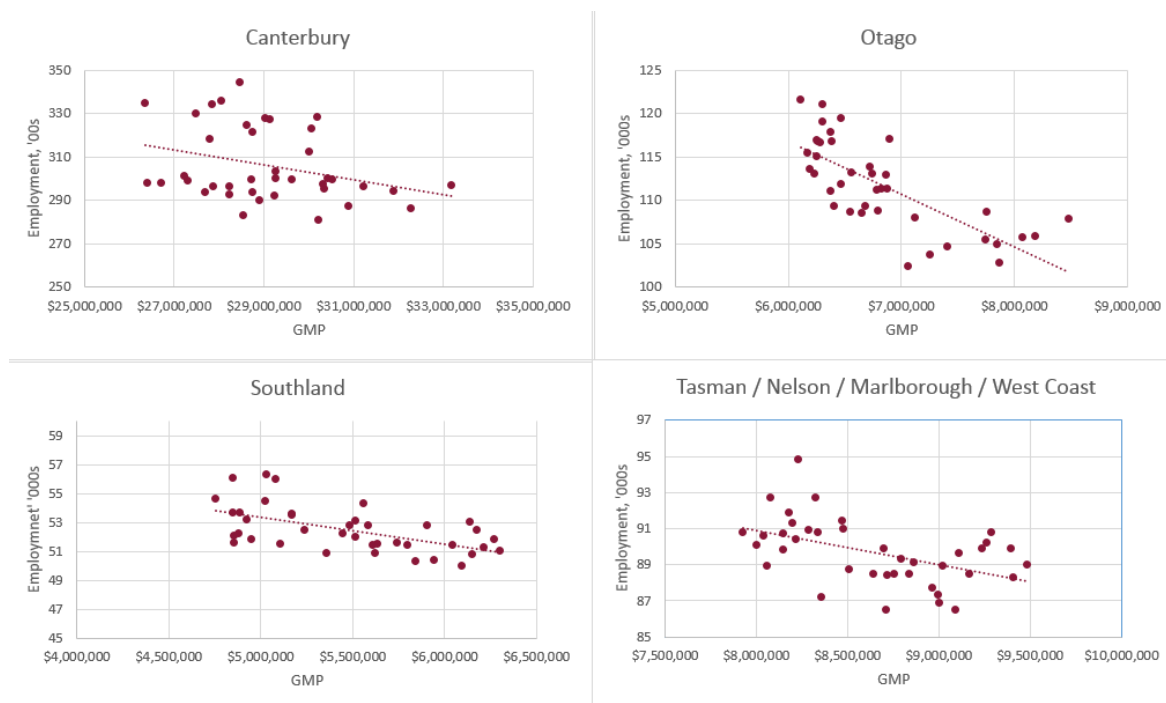


Figure 3-4 indicates that there is a negative relationship between GMP and employment in all four of the South Island areas shown.

Figure 3-4 GMP and employment, by South Island region, June 2007 – December 2016



Quarterly data on average weekly earnings is available on a quarterly basis for only four areas of New Zealand. Figure 3-5 indicates that GMP declines as earnings increase, whereas the opposite might have been expected.

Figure 3-5 GMP and average weekly earnings, June 2007 – December 2016



Figure 3-6 shows that there is a positive relationship between GMP and the number of venues in all North Island regions. This supports the national level finding in section 2.

Figure 3-6 GMP and number of venues, North Island regions, June 2007 – December 2016

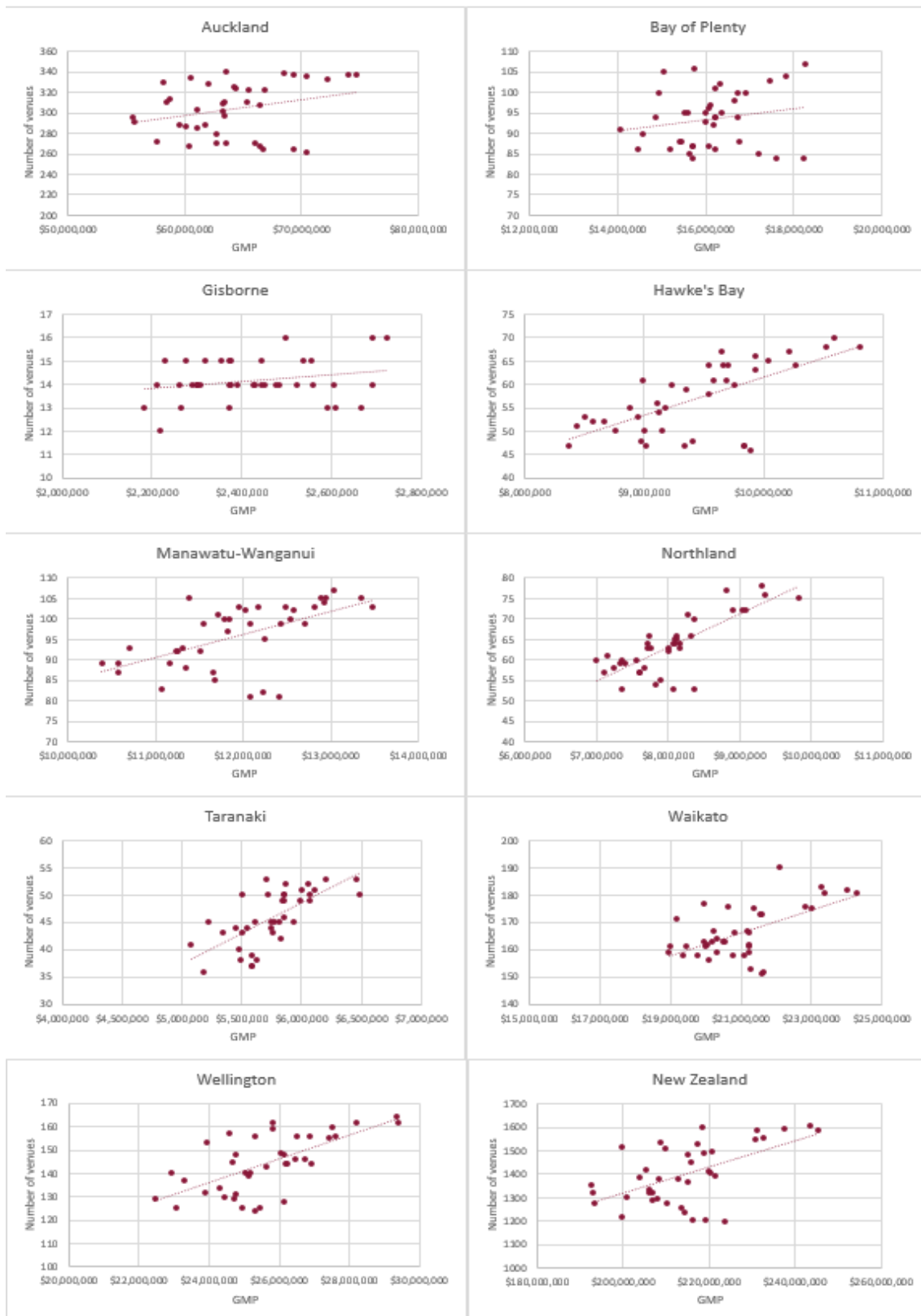


Figure 3-7 shows that Marlborough and Tasman are different from all other regions in New Zealand, in that there appears to be a negative relationship between GMP and the number of venues in those two regions. However, it will be noted that the numbers of venues in the two regions are small.

Figure 3-7 GMP and number of venues, South Island regions, June 2007 – December 2016

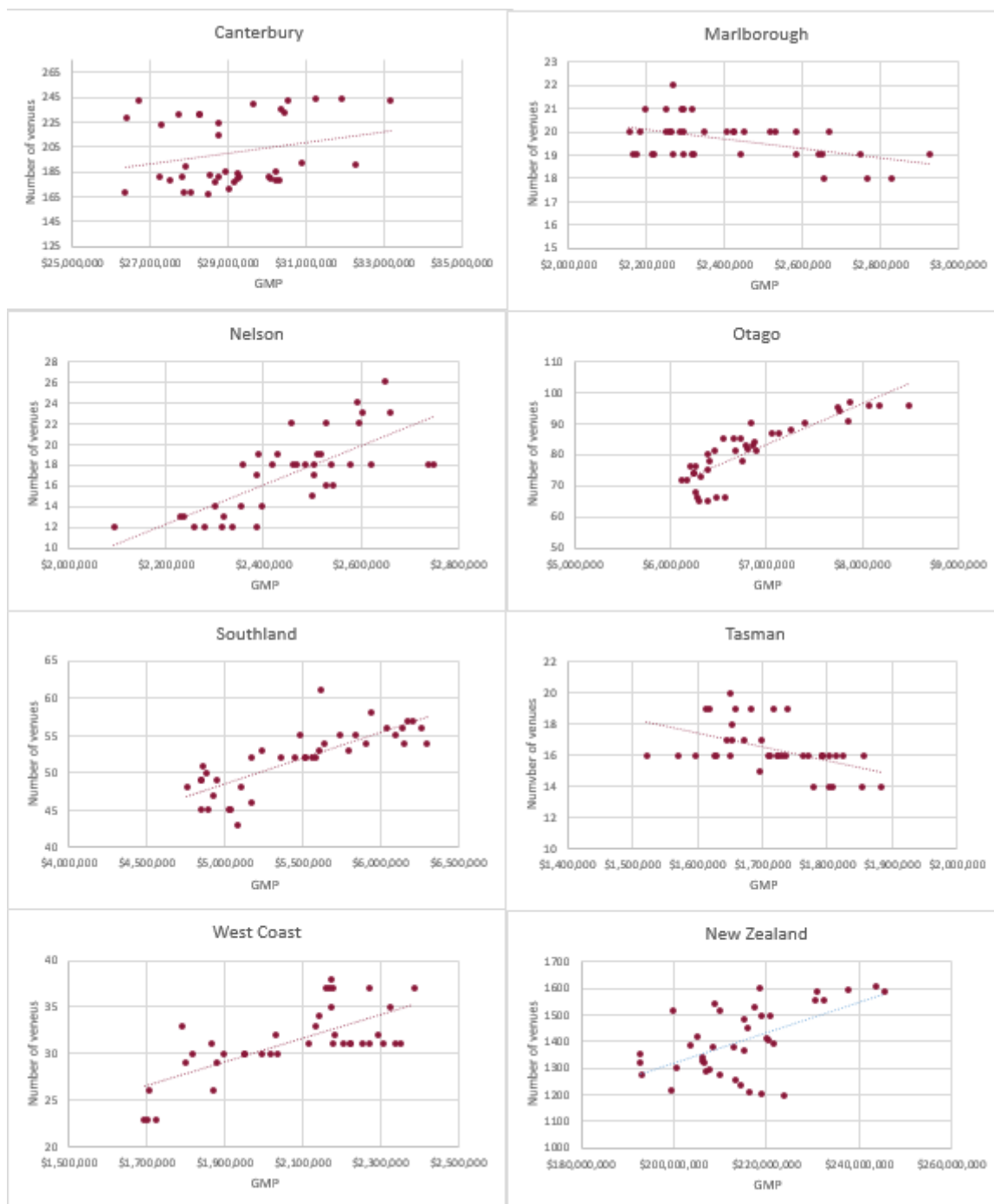


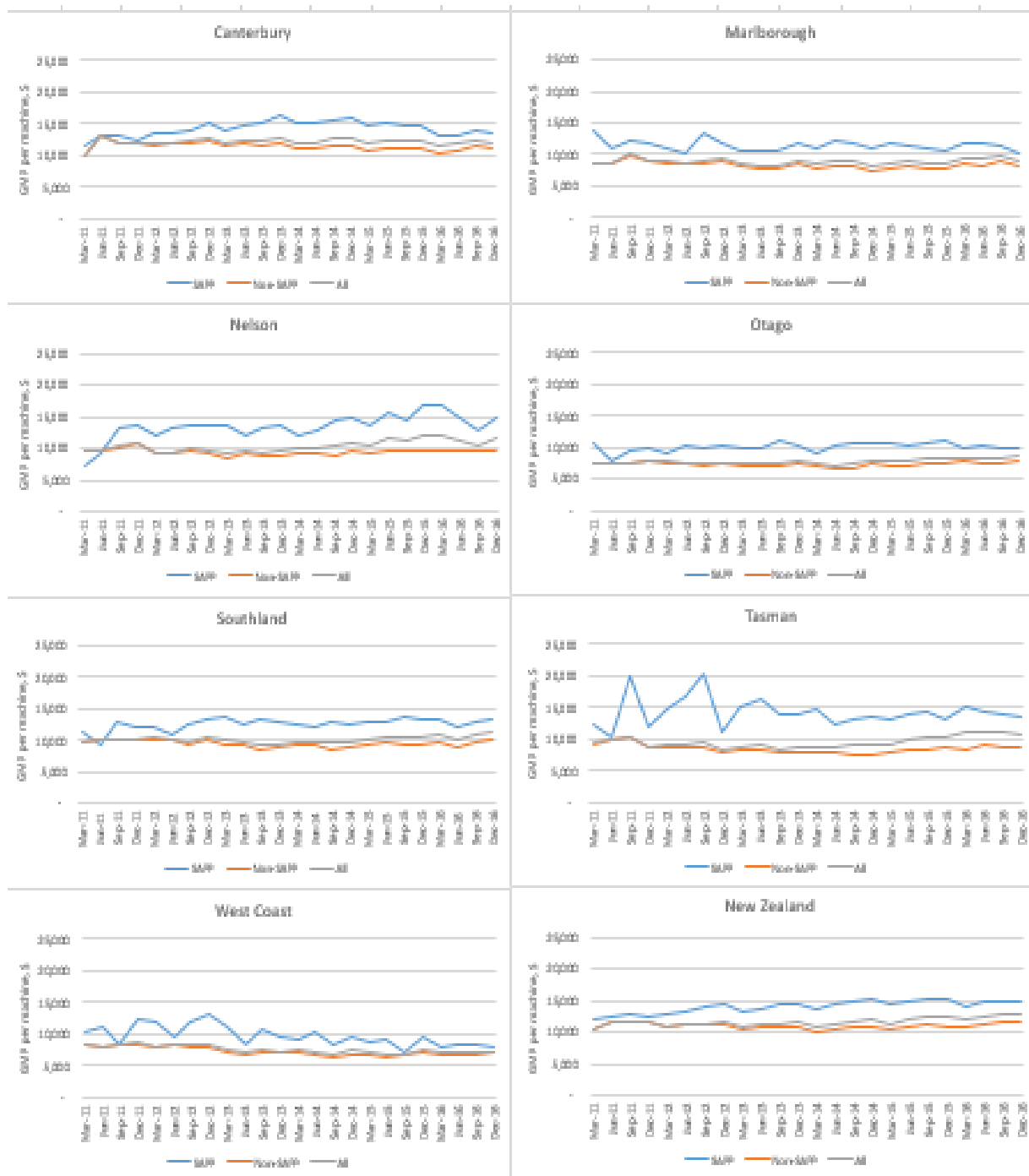
Figure 3-8 shows that GMP per SAPP is generally greater than GMP per non-SAPP in all North Island regions except Gisborne. However, perhaps the most important feature of the graph is that it shows that GMP on SAPPs has been sufficiently great in Auckland, Taranaki and Wellington to have a marked effect on overall GMP per machine.

Figure 3-8 GMP per machine, by North Island region, June 2007 – December 2016



Figure 3-9 again suggests that South Island regions do not necessarily conform to the norm when it comes to patterns of influence on GMP. GMP per SAPP machine is variable, quarter-by-quarter, in some of the regions; and, oddly, GMP per SAPP machine is clearly on a downward trend on the West Coast. It is also worth noting that GMP on SAPPs has been sufficiently great in a number of the regions, but especially in Tasman.

Figure 3-9 GMP per machine, by South Island region, June 2007 – December 2016



Overall, Figure 3-8 and Figure 3-9 reinforce the view that SAPPs have the greatest effect on GMP. We noted above that the introduction of SAPPs appears to have had the greatest impact on total GMP per machine in

Auckland, Taranaki, Wellington and Tasman; and it is probably no coincidence that the first three of these regions rank in the top three regions where SAPP machines account for the largest shares of the total number of machines, while Tasman is ranked fifth.

3.3 Multivariate analysis

The evidence presented above of multivariate analysis at the national level has come up inconclusive as to the effects of the macroeconomic variables considered.

We have employed a suite of statistical tests to uncover the relationship behind GMP spend and macroeconomic variables. We managed to find evidence of such a relationship only after SAPPs were introduced.

At a regional level it would serve little purpose reconsidering macroeconomic variables and their relationship with GMP. Since they have no relationship nationally, it is highly unlikely they would have a relationship regionally.

It is likely that the introduction of SAPP machines will have a statistically significant effect on the structure of GMP spend regionally. This should be the focus of such a regional analysis.

As previously acknowledged, GMP spend is an aggregation of a micro level phenomenon and there is no reason that macro level variables should have any bearing on it. In our analysis thus far we used these variables as proxies for what the true variables might be.

Therefore, with the data currently available future work should focus instead on models that consider the process of GMP spend on itself and a series of past randomness. I.e. ones that take the general form:

$$GMP_t - b_1 GMP_{t-1} - b_2 GMP_{t-2} - \dots - b_n GMP_{t-n} = \epsilon_t + c_1 \epsilon_{t-1} + c_2 \epsilon_{t-2} + \dots + c_n \epsilon_{t-n}$$

It would be wise to consider models that allow this process to shift once SAPP machines are introduced and there are econometric methods available that account for these effects.

As part of the process of diagnosing the national data we did fit such a model to the national GMP spend and found a good fitting specification. The results of this specification indicate that GMP spend is highly seasonal, predicted well by a single time period of GMP spend previous and two time periods of previous "shocks" or ϵ_t .

The trending component is of most interest here because we did find evidence that this fails to materialise if one omits data from periods after 2014. This indicates (but is not sufficient to conclude) that there has been a change in the behaviour of GMP spending that occurred around 2014.

Future models should draw on this analysis and extend it regionally. It is likely different regions will show different trends and reasons for this would be the subject of yet further work in identifying potential policy responses.

Aside from this, and outside the scope of our current analysis, regional work might consider the micro level determinants of GMP spend by individual gamblers. This is likely to lead to much more fruitful conclusions than macro level analysis.

Such analysis should take account of demographic effects, income, employment status as well as other behavioural traits. As part of attempting such an analysis a literature survey of New Zealand publications on gambling should be undertaken to assess the available data.

4 Conclusions

We have formulated univariate and multivariate analysis of GMP spend data from June 2007 to December 2016. We have shown how GMP spend trends downwards and then displays a marked uptick.

The univariate analysis at national level found that a number of variables that might be expected to have a positive relationship with expenditure actually have a negative relationship. Expenditure might be expected to increase as GDP, population, employment, earnings, consumer confidence and the number of international visitors increase, but the opposite appears to be true. However, there does seem to be a positive relationship between expenditure and the number of venues where gaming can happen, and between expenditure and the number of new-generation Stand Alone Progressive Prize (SAPP) machines. In addition, it was found that expenditure on Class 4 gaming has decreased at the same time as expenditure on other forms of gambling (Lotto, the TAB and Casinos) has increased. Moreover, expenditure on Class 4 Gaming has continued to fall behind expenditure on other forms of gambling, even since the introduction of SAPP machines.

The analysis of possible influences on expenditure at regional level was more restricted because there was less regional data available. However, the univariate analysis indicated a positive relationship between expenditure and employment in some regions, and a negative relationship in other regions. There was a more consistent, but counterintuitive negative relationship between expenditure and average earnings, while the relationship between expenditure and the number of venues was positive in all but one region. SAPPs have lifted expenditure per machine in most regions, but the effect seems to have been marked mainly in the larger regions, where SAPP machines account for a larger share of the total number of machines.

Interestingly, there appear to be differences between the North Island and the South Island in terms of trends in expenditure over time; and, to a lesser extent, in terms of the effect that the introduction of SAPPs has had. However, it has not yet been possible to fully explore the reasons for this.

We have also considered multivariate models of GMP spend and macroeconomic variables at a national level. This analysis came up inconclusive as to the effects of the macroeconomic variables. In addition, the analysis was also inconclusive as to the effect of introducing SAPP machines.

This statistical evidence lends weight to the evidence found in our univariate discussion. That evidence suggested that the introduction of SAPPs changed gambling behaviour. Our analysis provides a platform on which to discuss policy implications. Given our findings on the impotence of macroeconomic variables to explain GMP spend we think it would be more fruitful to examine the influences of gamblers' attributes on GMP.

Future statistical work, if any, should attempt to more conclusively diagnose the structural shift in GMP spend and ascertain in what period the shift occurred.

Appendix A Technical appendix: statistical test results and methods

We wanted to test if the variables in our model are *well behaved*. Formally this is known as a *unit root test* or an *Augmented Dickey-Fuller test*.

Table 4.1 Augmented dickey-Fuller test results

Augmented Dickey-Fuller test results

variable	ADF statistic
Log GMP	7.35
earnings (de-season, de-trend, 1st difference)	7.0704
venue numbers (de-trend, 1st difference)	8.6037
GDP (de-season, de-trend, 1st difference)	10.6247
Visitor numbers (de-season, de-trend, 1st difference)	10.1188

The test is such that if the numbers in the right hand column of Table 4.1 Augmented dickey-Fuller test results are greater than 6.73 we say we “reject the null hypothesis that there is a unit root”. This test helps reassure us that the transformations on the original variables have resulted in *well behaved* variables.

What this implies is that the variables are able to be explained by some real phenomena and are not simply a *random walk*.

From the results of this test we elected to drop the measure of population from the analysis as no transformation was sufficient to make the variable *well behaved*.

The final step of this part of the analysis was to model GMP spend as a function of all the transformed variables. The model in this case was (eq 1)

$$\ln(GMP)_t = \ln(GMP)_{t-1} + \ln(GMP)_{t-2} + \Delta earnings_{t-1} + \Delta earnings_{t-2} + \Delta Venues_{t-1} + \Delta Venues_{t-2} + \Delta Visitors_{t-1} + \Delta Visitors_{t-2} + \Delta GDP_{t-1} + \Delta GDP_{t-2} + z_t$$

In this model the Greek letter Δ means “change in” it is the difference between period t and period t – 1 of that particular variable. This differencing is generally accepted as a method to make the variables *well behaved*. Each variable is included in the model up to two periods in the past. The z_t on the end tells the reader that there is still randomness associated with the model. We have a set of assumptions about this variable that must be satisfied.

This model was chosen via a process of elimination to find the highest value of Akaike Information Criteria (AIC). We began with a specification of a single “lag” (past values) and considered models up to 5 “lags”. The current model of two “lags” resulted in the highest AIC.

As part of this process of elimination we also had to ensure the model conforms to our assumptions of z_t . Table 4.2 displays the results of the three tests we ran.

The right hand column contains the p-values of these tests. If the P-value is above 0.05 we say that we “fail to reject the null hypothesis”. In these particular tests it is desirable to reject the null hypotheses because that means the z_t is *well behaved*.

Table 4.2 Portmanteau test results

Portmanteau test results

Test	test statistic	p value
Serial correlation	286.02	0.9947
Heteroskedasticity	450	1
Normality	6.7701	0.747

We fit this model and determined through further generally accepted tests two important conclusions:

1. None of the variables *individually* explain the movement of GMP over time.
2. The variables *jointly* do not explain the movement of GMP over time.

These conclusions combined tell us that we have found a model that explains the data well, and the z_t are *well behaved*. But it also tells us that we need to consider further modelling (as the second *joint* test is only an indication in models with this structure, it is not conclusive).

The further modelling we did was to consider causality without making the mistake of *post hoc ergo propter hoc* (since event Y followed event X, event Y must have been caused by event X).

We ran a generally accepted methodology proposed by Granger (1969). This methodology attempts to decipher if the set of variables (GDP, visitor numbers, past values of GMP, earnings, venue numbers) *Granger-cause* the movement of GMP.

Our test results were inconclusive. We cannot reject the null hypothesis that those variables do not *Granger-cause* movements in GMP.

Because this test was inconclusive we decided to test the untransformed variables (the ones that are not *well behaved*) the test we conducted on these variables is one of *cointegration*. Loosely, this means that the variables “move together” through time because some underlying mechanism drives them both.

This theory is widely used in macroeconomics to explain the movements of the price level and other macroeconomic variables.

In our univariate analysis we showed simple linear (straight line) relationships between the variables. The following tests for *cointegration* will let us know whether those straight lines paint a reasonable picture of reality.

For this next test we fit a linear model for each of the five variables:

The model regressed each variable on every other variable

- 1) $\text{GMPTS_deseason} \sim \text{earnings_deseason} + \text{venueums} + \text{GDP} + \text{visnums_deseason}$
- 2) $\text{earnings_deseason} \sim \text{GMPTS_deseason} + \dots$
- 3) ...
- 4) ...
- 5) ... + GMPTS_deseason

Then we performed *Augmented Dickey-Fuller* tests on the results of these equations. In a similar vein as before we are looking for *unit roots*. If we find one that means that we have found an incidence of *cointegration*.

For this particular incidence we are looking for test statistics greater in absolute value than the value of -4.700 given by Granger and Yoo (1987).

Table 4.3 Augmented Dicky-Fuller test for cointegration

ADF test for cointegration

Variable	Test stat
Log GMP	-2.3531
earnings (de-season)	-2.6877
venue numbers	-3.1817
GDP (de-season)	-3.0241
Visitor numbers (de-season)	-5.6228

Looking at the right hand column of Table 4.3 we can see that all variables fail to reject the null hypothesis that there is no unit root. Except visitor numbers.

We conducted a further test to make sure these models were *well behaved*. All models were *well behaved* except that of visitor numbers. Therefore we must conclude that we have erroneously found cointegration between visitor numbers and GMP. This is shown in Table 4.4.

Table 4.4 Jarque Bera test for normality

Jarque Bera Test for normality

Variable	p value
Log GMP	0.5481
earnings (de-season)	0.5407
venue numbers	0.4132
GDP (de-season)	0.5198
Visitor numbers (de-season)	0.02002

Finally, to ensure we have an exhaustive list of tests we ran a variance ratio test and a multivariate trace statistic test. This procedure compliments the previous one by considering a model where the test statistic will be invariant to which variable is chosen as endogenous (the one at the start of the equation i.e. $GMP = \dots$)

Looking at the critical values and test statistics we see that the critical values are greater than the test statistics. Therefore we cannot reject the null hypothesis that there is a spurious relationship.

Table 4.5 Phillips-Ouliaris test

Phillips-Ouliaris method

Phillips-Ouliaris method	Test stat	critical value
Pu	4.4169	53.2502
Pz	59.6921	182.0749

The implication of this test is that the univariate linear relationships we found in the univariate analysis are most likely not a reflection of reality. The regressions cannot be said to not be *spurious*.

The variables move through time of their own accord and happen to move together at some points due to the onward march of time and not an underlying relationship.

This test indicates that the simple relationships we can see graphically are the result of the two variables being related only by time (i.e they both move over time) and so simple statistical techniques will pick up a relationship where none exists.

4.1.1 Long run models

So far we have only considered models of GMP as a function of two periods or less of the different variables. For our final test to attempt to explain the behaviour of GMP over time we decided to test a *long run* relationship.

The precise form of the model is the “short run” model seen in eq 1 plus a “long run” model as well as a “dummy variable” which counts how many SAPP machines are in New Zealand at that time period.

Our test was trying to divine firstly, if a long run relationship exists between the variables when SAPPs are explicitly included. And, if evidence is found, the form of that long run relationship.

We modelled 4 cases:

1. Two “lags”, linear trend and no SAPP dummy
2. Two “lags” linear trend and including SAPP dummy
3. Three “lags” linear trend and no SAPP dummy
4. Three “lags” linear trend and including SAPP dummy

H1: K = 2, no SAPP dummy

Cointegration rank: Trace statistic

	test	10pct	5pct	1pct
r <= 4	0.14	6.5	8.18	11.65
r <= 3	9.19	15.66	17.95	23.52
r <= 2	19.8	28.71	31.52	37.22
r <= 1	36.03	45.23	48.28	55.43
r = 0	84.92	66.49	70.6	78.87

Cointegration rank: Maximum Eigenvalue statistic

	test	10pct	5pct	1pct
r <= 4	0.14	6.5	8.18	11.65
r <= 3	9.05	12.91	14.9	19.19
r <= 2	10.61	18.9	21.07	25.75
r <= 1	16.23	24.78	27.14	32.14
r = 0	48.9	30.84	33.32	38.78

H2: K = 2, SAPP dummy included

Cointegration rank: Trace statistic

	test	10pct	5pct	1pct
r <= 4	0.67	6.5	8.18	11.65
r <= 3	8.74	15.66	17.95	23.52
r <= 2	21.49	28.71	31.52	37.22
r <= 1	42.31	45.23	48.28	55.43
r = 0	94.7	66.49	70.6	78.87

Cointegration rank: Maximum Eigenvalue statistic

	test	10pct	5pct	1pct
r <= 4	0.67	6.5	8.18	11.65
r <= 3	8.07	12.91	14.9	19.19
r <= 2	12.75	18.9	21.07	25.75
r <= 1	20.82	24.78	27.14	32.14
r = 0	52.38	30.84	33.32	38.78

H3: K = 3, no SAPP dummy

Cointegration rank: Trace statistic

	test	10pct	5pct	1pct
r <= 4	0	6.5	8.18	11.65
r <= 3	5.09	15.66	17.95	23.52
r <= 2	18.94	28.71	31.52	37.22
r <= 1	40.17	45.23	48.28	55.43
r = 0	86.42	66.49	70.6	78.87

Cointegration rank: Maximum Eigenvalue statistic

	test	10pct	5pct	1pct
r <= 4	0	6.5	8.18	11.65
r <= 3	5.09	12.91	14.9	19.19
r <= 2	13.85	18.9	21.07	25.75
r <= 1	21.23	24.78	27.14	32.14
r = 0	46.25	30.84	33.32	38.78

H4: K = 3, SAPP dummy included

Cointegration rank: Trace statistic

	test	10pct	5pct	1pct
r <= 4	0.55	6.5	8.18	11.65
r <= 3	1.59	15.66	17.95	23.52
r <= 2	19.11	28.71	31.52	37.22
r <= 1	44.07	45.23	48.28	55.43
r = 0	94.02	66.49	70.6	78.87

Cointegration rank: Maximum Eigenvalue statistic

	test	10pct	5pct	1pct
r <= 4	0.55	6.5	8.18	11.65
r <= 3	1.04	12.91	14.9	19.19
r <= 2	17.51	18.9	21.07	25.75
r <= 1	24.96	24.78	27.14	32.14
r = 0	49.95	30.84	33.32	38.78

This procedure allows us to diagnose what the "order" of the way the variables "move together" is. In all the tables produced above we are looking for a *Test* that is greater than the corresponding number in the column labelled "5pct". Ideally, for each of H1,...,H4 we'd like the Trace and the Maximum Eigenvalue statistic to agree on what *level* ($r = 1, \dots, 4$) is statistically significant.

Running through each of the above tables it is evident that **in no model do we find any evidence of a cointegrating relationship between GMP spend and the macroeconomic variables.**

Therefore the evidence suggests macroeconomic variables do not impact GMP spend. **And, further, that introducing SAPP machines does not impact GMP spend through the relationship with macroeconomic variables.**