Department of Economics, University of Warwick

Monash Business School, Monash University

as part of

Monash Warwick Alliance

Do economic impact assessments of motorsport events overlook a human capital cost from changes in spectators' driving behaviour? An investigation into the Australian Formula One Grand Prix

Jack Doughty

Warwick-Monash Economics Student Papers

September 2022 No: 2022-36

ISSN 2754-3129 (Online)

https://warwick.ac.uk/fac/soc/economics/research/wmesp/

The Warwick Monash Economics Student Papers (WM-ESP) gather the best Undergraduate and Masters dissertations by Economics students from the University of Warwick and Monash University. This bi-annual paper series showcases research undertaken by our students on a varied range of topics. Papers range in length from 5,000 to 8,000 words depending on whether the student is an undergraduate or postgraduate, and the university they attend. The papers included in the series are carefully selected based on their quality and originality. WM-ESP aims to disseminate research in Economics as well as acknowledge the students for their exemplary work, contributing to the research environment in both departments.

"*We are very happy to introduce the Warwick Monash Economics Student Papers (WM-ESP). The Department of Economics of the University of Warwick and the Economics Department at Monash University are very proud of their long history of collaboration with international partner universities, and the Monash Warwick Alliance reflects the belief in both Universities that the future will rely on strong links between peer Universities, reflected in faculty, student, and research linkages. This paper series reflects the first step in allowing our Undergraduate, Honours, and Masters students to learn from and interact with peers within the Alliance.*"

Ben Lockwood (Head of the Department of Economics, University of Warwick) and Michael Ward (Head of the Department of Economics, Monash University)

Recommended citation: Doughty, J. (2022). Do economic impact assessments of motorsport events overlook a human capital cost from changes in spectators' driving behaviour? An investigation into the Australian Formula One Grand Prix. *Warwick Monash Economics Student Papers* 2022/36.

[1] Warwick Economics would like to thank Lory Barile, Gianna Boero, and Caroline Elliott for their contributions towards the selection process.

Do economic impact assessments of motorsport events overlook a human capital cost from changes in spectators' driving behaviour? An investigation into the Australian Formula One Grand Prix

Jack Doughty*

Abstract

This research project intends to further contribute to academic literature surrounding the relationship between motorsport events and spectators' driving behaviour. Namely, it attempts to determine if there is a quantifiable human capital cost to Victoria's economy from greater motor vehicle crashes (MVCs) over the course of the Australian Formula One Grand Prix event. In examining VicRoads traffic incident data from 2006 to 2019, this analysis finds statistically significant evidence to suggest there is on average +7.05 to +13.01 more high-speed MVCs in Victoria throughout the Australian Formula One Grand Prix event. In attempting to improve the accuracy of economic impact assessment methodology, this translates to a previously ignored expected human capital cost to Victoria's economy when a Formula One event is hosted of $1,326,450.52 to $2,447,818.62. In response, this research project contends that economic impact assessments for motorsport events must include a calculation of the human capital cost from a change in spectators' driving behaviour.

JEL Classifications: Z20

Keywords: Economic impact assessment, motorsport, human capital cost

* Contact information: jack@doughty.com

1. Background

The four-day Australian Formula One Grand Prix event (the Event) has been an integral component of the Victorian sporting calendar since 1996, when the inaugural F1 race was held around the newly constructed Albert Park Circuit in Melbourne (Tranter & Lowes, 2005). Famously, this came after the Victorian Government paid a sanction fee of $6m to the Formula One in order to obtain the rights to the Event from Adelaide, who had hosted over the 11 years prior (Fogarty, 2016). Since then, the Victoria-based Event has regularly attracted over 300,000 spectators each year to Albert Park across the four-day Event (Grand Prix, 2022), with an additional 886,000 domestic viewers watching on Sunday via broadcast in 2022 (Perry, 2022). At such a high level of viewership, the branding value of the Event alone to the state of Victoria has been estimated at an advertising-equivalent value of $35.6m (Tourism Victoria, 2011). With such high branding exposure, it is unsurprising that New South Wales Premier Dominic Perrottet has announced his intention to "poach the race" for Sydney by 2025 (Weiss, 2022), just as Jeff Kennett did for Melbourne in 1993 (Fogarty, 2016). Under such competition, the question must be asked, why is the Australian Formula One Grand Prix such a desirable event for a state government? Or perhaps more importantly, what is the overall benefit to a state from hosting a motorsport event such as the Australian Formula One Grand Prix?

To answer that question is to undertake an economic impact assessment; a formalised analysis of the marginal economic impact of an investment decision within a regional economy (EY, 2022). These studies are typically conducted by a third party, and in theory, provide the governing authority with an unbiased and objective view of the economic contribution of an investment to a region. In 2011, Tourism Victoria and the Victorian Government engaged third party Ernst & Young to conduct a study on the economic impact of the Formula One Australian Grand Prix for the Victorian economy. The purpose of the study was to quantify the net benefit, if any, that the Event contributes as a whole within the state of Victoria. At a surface level, this analysis would allow the Victorian Government to understand the economic significance of the Event, and act as a reference point for future funding and policy decisions (Tourism Victoria, 2011).

In adopting a CGE (Computable General Equilibrium) model, the Ernst & Young report compared the state of the Victorian economy with and without the Event against both overseas and domestic counterfactuals (Tourism Victoria, 2011). The methodology first addressed the direct economic impact, recognised as the marginal change in expenditure by key stakeholders (spectators, media, staff, and racing organisations) within the economy as a result of hosting the Event. Then, it targeted the indirect flow-on impact of this economic shock through the MONASH Multi-Region Forecasting (MMRF) model. This model mimics the "behaviour of households and industries" in Victoria as a result of an exogenous economic shock (Tourism Victoria, 2011). Having aggregated these effects, the report attributed the 2011 Formula One Australian Grand Prix in Melbourne with an annual relative net increase of between $32m and $39m in Victorian Gross State Product (EY, 2011). Moreover, approximately 350-411 full-time jobs were expected to have been created from hosting the Event in 2011 (EY, 2011). As a result of this quantitative analysis, Tourism Victoria concluded that "hosting the Formula One Australian Grand Prix brings significant benefits to Victoria" over the four-day Event (Tourism Victoria, 2011).

In challenging the accuracy of this economic impact assessment, one must first be conscious of the time and resource constraints facing the authors. Attempting to model the entire economic impact of an exogenous shock is a difficult task which will always require certain assumptions and a constrained scope. In short, there are two types of critiques levelled against economic impact assessments more broadly; those which question the moral hazard and personal incentives of the governing bodies and engaged third party (see Scandizzo & Pierleoni, 2017), and those that attempt to improve best-practice methodology. The former generally recognises the tendency for the "high expectations" and "ambition" of commissioning authorities to bias results towards a positive outcome (Kasimati, 2006). Given the political nature of commentary required to discuss this notion in depth, this research project will instead focus on exploring the latter within the context of the Australian Formula One Grand Prix.

2. *Introduction*

Existing academic literature has frequently supported a narrative in which the entertainment we consume has a direct causal impact on our practiced behaviours and actions (Anderson, 2002). For instance, violent video gameplay has been shown to be related to aggressive behaviour (Anderson & Dill, 2000), while watching medical dramas on television has subsequently been linked with an increased likelihood of organ donation (Morgan et al., 2009). In the case of motorsport entertainment which glamorises high-speed driving, might we anticipate a similar demonstration effect to have a relationship with spectators' driving behaviour?

Previous studies conducted with Australian drivers have found that "higher levels of interest in motor racing" are strongly associated with greater "pro-speeding attitudes" (Tranter & Warn, 2008). In turn, appetite for speed and thrill-taking has power in predicting the frequency of a driver's violations on public roads (see Yenier et al., 2015 and Turner & McClure, 2003). Moreover, high-speed driving has been proven to be significantly predictive of accident involvement (Tranter & Lowes, 2005). It would seem plausible then, to infer that motor racing spectators may exhibit greater risk-taking behaviour on public roads, and hence be more likely to cause an accident by driving at higher speeds. That narrative is supported by a 2018 study of NASCAR races in West Virginia, which indicated that televised races were connected to "substantial increases in the incidence of speed-related MVCs" (Roden-Foreman et al., 2019). Given access to only monthly crash data, this analysis was largely limited in scope by examining only monthly averages and was not able to provide evidence at an overly granular level. After all, the results could not prove with any certainty that the uplift in high-speed crashes coincided with the exogenous shock of a NASCAR event rather than occurring in the weeks before. In conducting the study, the authors themselves recognised the necessity for more granular data which is currently "impossible to obtain" in the U.S.A. (Roden-Foreman et al., 2019). Nevertheless, the report undeniably develops some evidence to support a relationship between high-speed accidents and motorsport entertainment.

Not since the year 2000 has this relationship been explored within the context of the Australian Formula One Grand Prix, however. In 1986, Fischer, Hatch and

Paix conducted an investigation into road behaviour during the 1985 Adelaide Grand Prix period, finding a 34% increase in the level of severe motor vehicle crashes (Fischer et al., 1986). This "hoon effect" was hypothesized to be driven by spectators attempting to "emulate their Formula One heroes" through reckless driving behaviour (Fredline et al., 2008). Additional evidence has been presented to contend that accident rates more than doubled in suburbs surrounding Albert Park following the inaugural Formula One event in 1996 (Bannerman, 2000). This, in part, is likely due to greater traffic complexity and uncertainty with altered road networks during the race week. Alternatively, motorists may be more broadly engaging in dangerous road behaviour, emulating the activity of race car drivers (Tranter & Lowes, 2005).

The landscape in which the Australian Formula One Grand Prix operates has drastically changed since the year 2000, with over 95 million fans engaging online with race content in 2019 (Australian Grand Prix Corporation, 2019). Meanwhile, the academic literature surrounding driving behaviour following exposure to motorsport in Australia has grown dated and would benefit from research with current accident data. Studies conducted surrounding NASCAR races of 2018, although recent, are instead limited by a lack of granularity in road accident data. Hence, in leveraging access to daily VicRoads accident data for the state of Victoria from 2006 to 2019, this report seeks to investigate the relationship between the Australian Formula One Grand Prix and road accidents in both a modern context and on a granular level. In taking a human capital approach to calculating the economic burden to Victoria of an uplift in motor vehicle crashes, this study intends to extend the accuracy of economic impact assessments conducted for motorsport events by accounting for an additional cost consideration.

3. Hypotheses

In exploring the academic literature, we develop three key hypotheses to test in this empirical study. As the core premise of this report, we firstly wish to explore more generally whether there is uplift in MVCs with Victoria hosting the four-day Event relative to not hosting the Event. Hence, the first hypothesis is as follows:

(1) There is an increase in all MVCs in Victoria over the course of the Australian Formula One Grand Prix event.

Secondly, given research from Turner and McClure (2003), we anticipate that men in particular will be susceptible to reckless behaviour on public roads under exposure from the Event from Thursday until Sunday. Therefore, the second hypothesis to be explored is:

(2) There will be an increase in MVCs among men over the course of the race weekend relative to women, given an expected greater interest level in motorsport and aptitude for reckless driving (Turner & McClure, 2003).

Thirdly, in developing the 2019 analysis of Roden-Foreman et al., we would anticipate greater high-speed accidents over the course of the Event. This is in line with the findings of Fischer et al. for the 1986 Adelaide Grand Prix (Fischer et al., 1986), contending that driver behaviour imitates that of Formula One drivers. As a result, our final hypothesis is as follows:

(3) There will be an increase in high-speed MVCs over the course of the Australian Formula One Grand Prix event.

4. Data

The key to successfully assessing these hypotheses lies within the strength of the dataset. Roden-Foreman et al. highlighted the constraint of a lack of "granularity" in undertaking similar analysis within the context of NASCAR races in West Virginia, with only monthly averages acting as an explanatory variable (Roden-Foreman et al., 2019). Hence, the first step in determining the relationship between the Event and spectator road accidents is to develop a sophisticated dataset.

In order to accurately assess the hypotheses developed in section three, a complete dataset had to be developed with a detailed description of driver characteristics, the speed at which the driver was travelling at the time of the incident, and an exact date and time. While such a dataset is not released from

VicRoads or the Department of Transport, instead, there are two datasets available; one which details the time and place of an accident, and another with the characteristics of each individual involved in the accident (drivers and passengers alike). It is worth noting that these datasets are comprised of all accidents on public roads which were reported to police in the state of Victoria from 2006 to 2022. Driver and crash characteristics, therefore, remain as identified by police officers completing the accident report. As noted by Roden-Foreman et al., while this is perhaps not a comprehensive dataset of all traffic incidents, it is “unlikely that societally or health-care related crashes would not result in police reports” (Roden-Foreman et al., 2019).

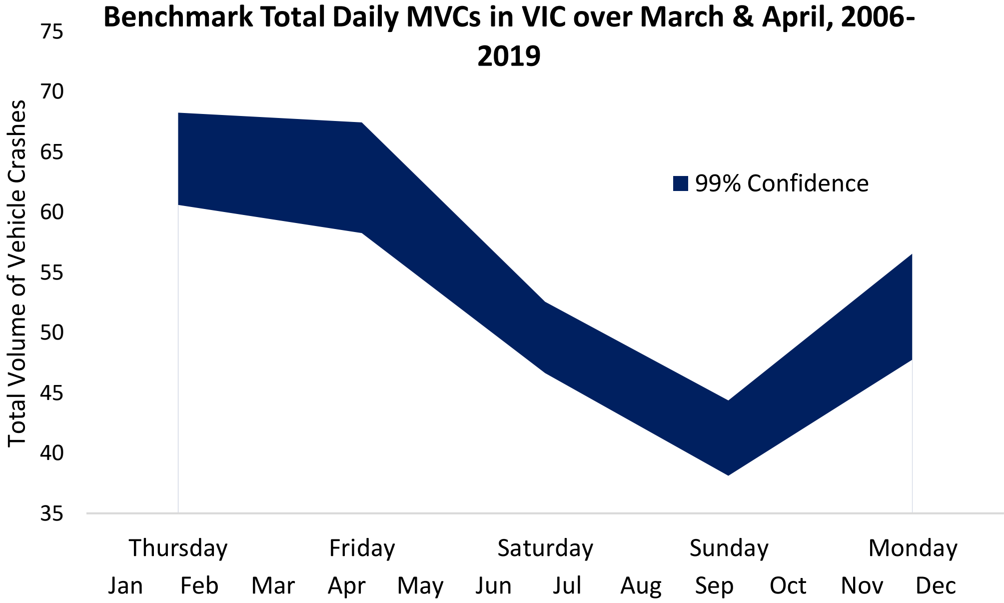
Having matched over 400,000 accidents across the two datasets through common identifying features, the combined dataset was further refined through the removal of passengers, and drivers of vehicles other than cars. This is an intuitive decision, as passengers are not causally responsible for road accidents and hence their information is not relevant at this stage of analysis, while motorcyclists and large vehicle drivers were determined to be less likely to imitate the behaviour of car drivers over the course of the Formula 1 Australian Grand Prix event. Next, observations following the outbreak of the coronavirus were eliminated, as not only did this act as a structural break in trends of road traffic but was also not relevant given that the Australian Formula One Grand Prix was cancelled in both 2020 and 2021.

The Australian Transport Assessment and Planning (ATAP) Guidelines, provided by the national Department of Infrastructure and Regional Development, are a set of best-practice industry frameworks for transport assessment and planning. One such framework provides parameters for the average human capital cost of a motor vehicle crash to the Victorian economy, categorised by the severity of injury and speed at which the crash took place (see **Fig. 6.1**). The human capital approach adopted accounts for three categories of cost: human costs, vehicle costs, and general costs. Broadly speaking, human costs account for medical bills, correctional services, changes to quality of life, and a marginal loss of labour supply. Vehicle costs, on the other hand, capture repairs and the implicit economic cost of vehicle unavailability. Finally, general costs refer to the burden from accessing emergency services, travel delays, and insurance administration (ATAP, 2010). These values are derived from studies undertaken in 1996 and are updated on an annual basis using various price-related indices. While the study may be outdated, in the interest of efficiency these indexed values will be assumed sufficiently accurate. The adjusted parameters will be used to determine the total human capital cost to Victorian society from additional MVCs over the course of the Event.

5. Approach

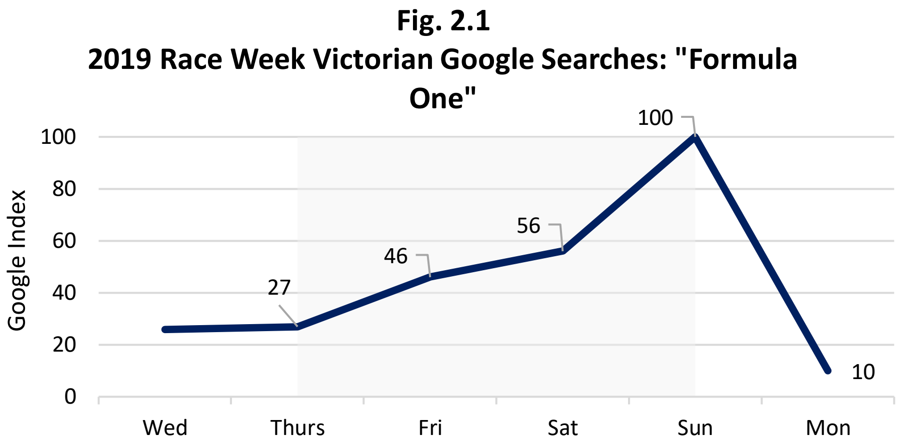
In addressing the research question, it is important to recognise that traffic incident data is highly seasonal in nature, with monthly MVC fluctuations driven by weather conditions and social calendars, while weekly fluctuations are driven by traffic volume (see Smith, 1982 and Keay & Simmonds, 2005).

Fig. 1.2
Benchmark Total Daily MVCs in VIC over March & April, 2006-2019



With such clear monthly and weekly trends as shown in **Fig. 1.1** and **Fig 1.2** respectively, the first step in this analysis is determining a methodology to negate the impact of seasonality. Then, we can begin to examine each of the three hypotheses. In handling monthly seasonality, this analysis benefits from the changing F1 calendar, with the Melbourne-based event being held as early as the first week of March, and as late as mid-April over the 2006-2019 period. We therefore limit our dataset to the three weeks before and after the Event for each given year; for a subset of 686 days and 38,509 MVCs. The general randomness of the F1 calendar naturally accounts for seasonal fluctuations in weather conditions over the March and April period, and ensures monthly seasonality will not skew results. As for weekly seasonality, utilising the average motor vehicle accidents from these three weeks before and after the Event acts as a benchmark for comparison on each day of the week. In doing so, average weekly fluctuations are accounted for, and observations over the course of the Event can be compared to the expected trend.

Having developed an approach that can handle seasonality, we wish to conduct T-Tests for the difference in means of MVCs between the Event and the benchmark for each day of the week (hypothesis (1)). While the Formula One race itself is held on the Sunday, there is substantial motorsport entertainment held over the course of Thursday, Friday and Saturday that must be acknowledged. This entertainment includes the Formula One qualifying, multiple Formula One warm-ups, Supercar racing, the Porsche Carrera Cup, and numerous historic car driving demonstrations (Butler, 2022). While 419,000 spectators attended Albert Park over the course of the Event in 2022, over 290,000 of them did not attend Sunday's Grand Prix whatsoever. As such, although we would still anticipate the largest exposure to motorsport to be on Sunday given that 886,000 domestic fans tuned in via television, it is vital to note the relevance of the three days prior (Perry, 2022). After all, a large number of visitors to Albert Park in 2022 experienced motorsport entertainment across Thursday (55,000), Friday (112,000) and Saturday (123,000) (Brittle, 2022). As shown in **Fig 2.1**, a profile of 2019 Google Search trends over the course of the Event, there is a clear growing interest in searches for the term 'Formula One' from Thursday until Sunday, before receding towards zero on Monday. Hence, we would anticipate that overall engagement with motorsport entertainment online rises in the build-up to Sunday.



Despite experiencing a tapering off in the level of interest in Google Trends data (from 100 to 10 in the Google Index indicator), we also choose to initially examine data from the Monday following the Event in order to investigate any spill-over effect from observed behaviour. We limit the scope of our analysis beyond the Event at this point, given that the argument for a direct relationship becomes tenuous as we move further into the future, and we would begin double-counting observations as weekly profiles overlap.

In controlling for driver characteristics while conducting Welch's T-Tests for differences in means between the Event and the benchmark, we can assess the role of demographic and speed (see hypotheses (2) and (3)). In addressing hypothesis (2), we categorise data by gender, creating a new 'interest group' variable for men that can be compared to women in the 'control group'. The importance of the combined dataset containing driver characteristics detailed in part IV is evident here, allowing for analysis between trends in MVCs for different groups. For hypothesis (3), we categorise crashes as 'high-speed' if the driver was travelling at a speed of 70km/h or greater, and 'low-speed' if otherwise. The decision to identify a cut-off at 70km/h is based on the Transport Accident Commission's research that at this speed, unlike 60km/h, reaction times become inconsequential in avoiding an accident through braking (TAC, 2001). Although largely an arbitrary choice, the significance of the 70km/h cut-off will become more evident in part VI. For hypothesis (2) we conduct a difference-in-differences T-Test between our interest and control group, in order to determine whether gender plays a role in trends in driver behaviour over the course of the Event. As for hypothesis (3), we first conduct a difference-in-differences T-Test to assess the change in driving behaviour for high-speed MVCs in particular. In this case, we utilise the volume of low-speed MVCs to control for exogenous factors such as weather conditions, traffic, and additional systematic noise. In a less conservative approach, we also conduct a difference in means T-Test between the Event week and benchmark weeks in order to identify any significant uplift in high-speed driving behaviour, assuming our seasonality controls sufficiently manage these omitted variables. In doing so, we can identify if any significant absolute uplift in motor vehicle crashes exists and proceed with assigning a dollar value to the expected economic burden of these crashes to the state of Victoria.

The purpose of this analysis is to identify any uplift in MVCs as a result of hosting the Formula One Australian Grand Prix in Victoria, in order to then infer the marginal burden of such an uplift on the Victorian economy. Hence, the second step in this methodology is identifying the weighted average social cost per crash based on significant crash characteristics, to then be multiplied by the expected uplift in MVCs and calculate a total expected burden.

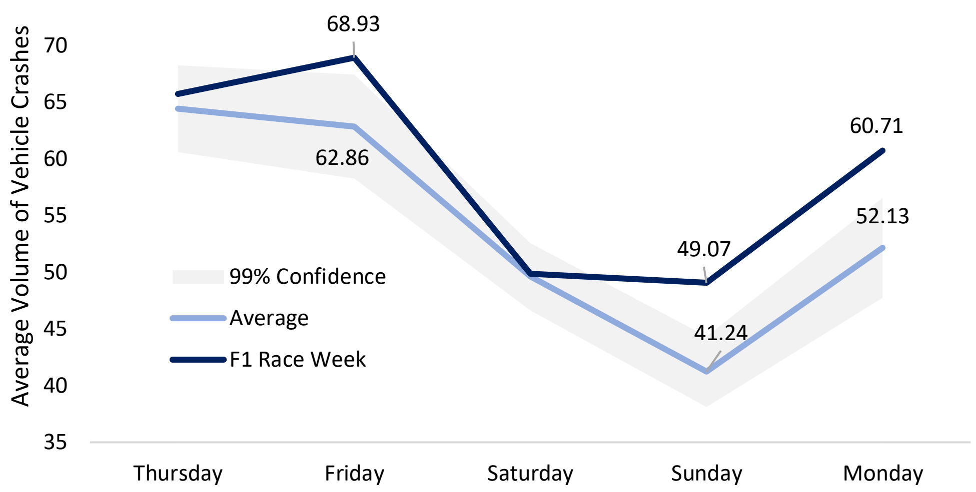
$$w = \frac{\sum_{x,s}(f(x,s) \times \ c_{x,s} \times p_{x,s})}{n}$$

This weighted average cost per crash (w) is calculated by first multiplying the per-person parameters (c) provided in the ATAP Guidelines (see **Fig. 6.1**) by frequency ($f()$) of crashes at each speed (x) and severity (s). This value is then multiplied by the average number of passengers per vehicle (p) at each speed and severity. Then, the total cost is divided by the number of crashes in the sample (n) to determine the weighted average cost per crash (w) over the course of the Event. This value is then multiplied by the relevant uplift in motor vehicle crashes to determine the total human capital cost to Victoria over the course of the Event.

6. Results

The first step in addressing hypothesis (1) is creating a visualisation to compare the average total motor vehicle crashes over the course of the Event relative to our benchmark weeks. Having constructed a 99% confidence interval for each day of the week using 32,676 crashes from the benchmark dataset, we can overlay the average MVCs for the Event from 2006 to 2019 and create a graphic of this data. In this visualisation, data labels are included for days in which the Event mean exceeds the 99% confidence interval of benchmark data.

Fig. 3.1
Average Total MVCs in VIC, March & April '06 - '19



As shown in **Fig 3.1**, the average number of MVCs over the Event is elevated above the 99% confidence range on Friday, Sunday, and Monday. The differences in mean between the Event average and benchmark average on these days are +6.07, +7.83, and +8.58 total MVCs respectively. There are several interesting takeaways from this visualisation. Firstly, there is clear uplift in overall MVCs in Victoria over the course of the Event relative to the benchmark between 2006 and 2019. This includes uplift, as expected, on both the Friday and Sunday. There is additional uplift on the Monday following the Event, which was not anticipated. Surprisingly, there is no noticeable difference between means on the Saturday; the day of Formula One Race Qualifying. These results point to a general elevation in motor vehicle crashes over the four-day motorsport Event and would lead us to tentatively support our first hypothesis. However, before conducting a test for significance, it is important to break data down by driver characteristics and speed to further assess trends driving uplift in MVCs over the course of the Event. After all, in their study of NASCAR race data, Roden-Foreman et al. opted to focus on purely high-speed MVCs alone, arguing that the vast majority of driver behaviour remains consistent (Roden-Foreman et al., 2019).

In addressing hypothesis (2), we visualise trends in MVCs for both our interest group, men, and control group, women, over the course of the Event. As discussed, we would anticipate Victorian men to display more reckless behaviour in response to motorsport entertainment, as the 'main audience' of the Formula One traditionally (Tranter & Lowes, 2005) with a typically greater appetite for risk-taking behaviour on the road according to established academic literature (Turner & McClure, 2003).

Fig. 4.1
Men in MVCs in VIC, March & April '06 - '19

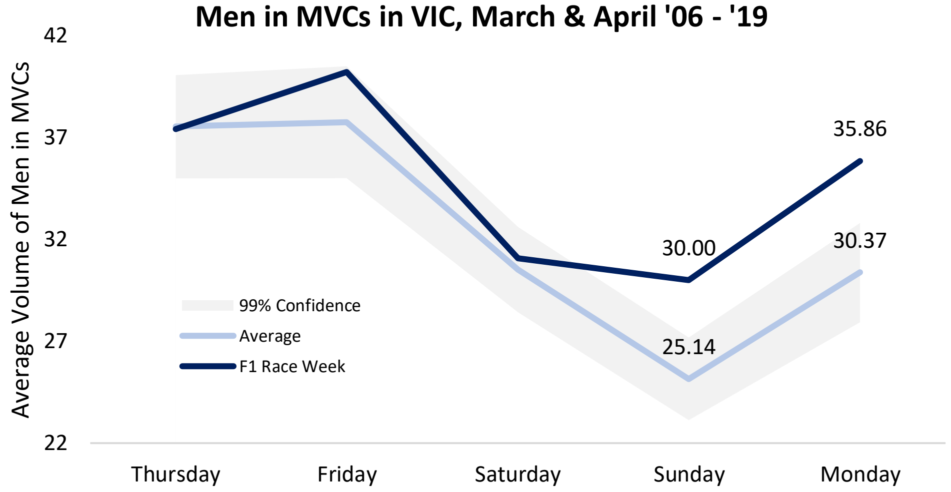
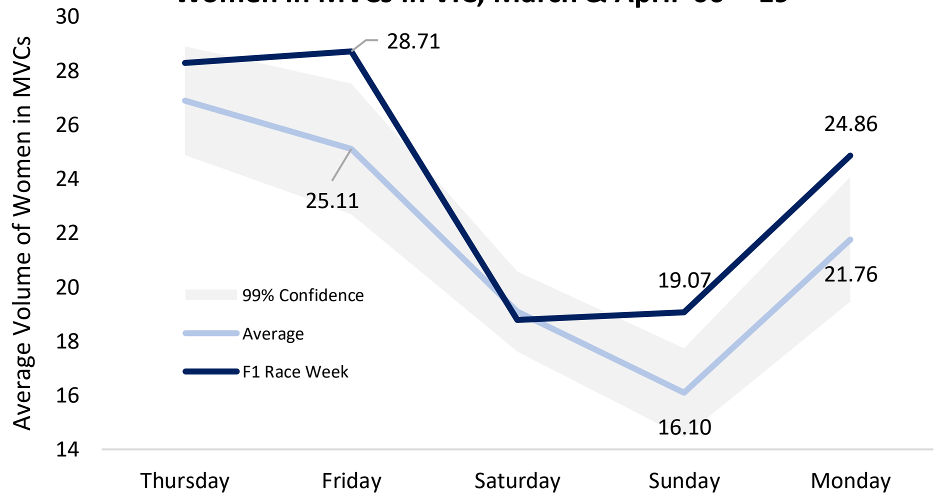


Fig. 4.2
Women in MVCs in VIC, March & April '06 - '19



The findings presented in **Fig. 4.1** and **Fig. 4.2** are somewhat contradictory to the research of Turner & McClure (2003) and Fischer et al., (1986), with both men and women displaying similar average MVC profiles throughout the Event. There is uplift in MVCs beyond the 99% confidence interval on Sunday and

Monday for men, and Friday, Sunday and Monday for women. This uplift is approximately +10.35 and +9.67 MVCs for men and women respectively across Victoria. While we are undoubtedly interested in this absolute uplift in MVCs, we are more interested in understanding whether the difference-in-differences between men and women coinciding with the motorsport entertainment of the Event is significant. Hence, we can use Welch's T-Test to compare the 'Benchmark Difference' against the 'Event Difference'. We use a T-Test in this case to test the likelihood that the two constructed variables belong to the same underlying distribution. Rather than utilising the Student's T-Test, we utilise Welch's T-Test to account for the noteworthy differences in sample sizes between the Event and benchmark samples, as we would anticipate different variances in these two data arrays. Our null hypothesis, derived from hypothesis (2), is that the difference between the number of men and women involved in MVCs does not increase from the average over the course of the Event. The results of our one-tail test can be seen in **Fig. 4.3** below, for Thursday to Monday.

Fig. 4.3 Men vs. Women MVCs Difference in Differences Test

(*=1%, **=5%, *=10%)**

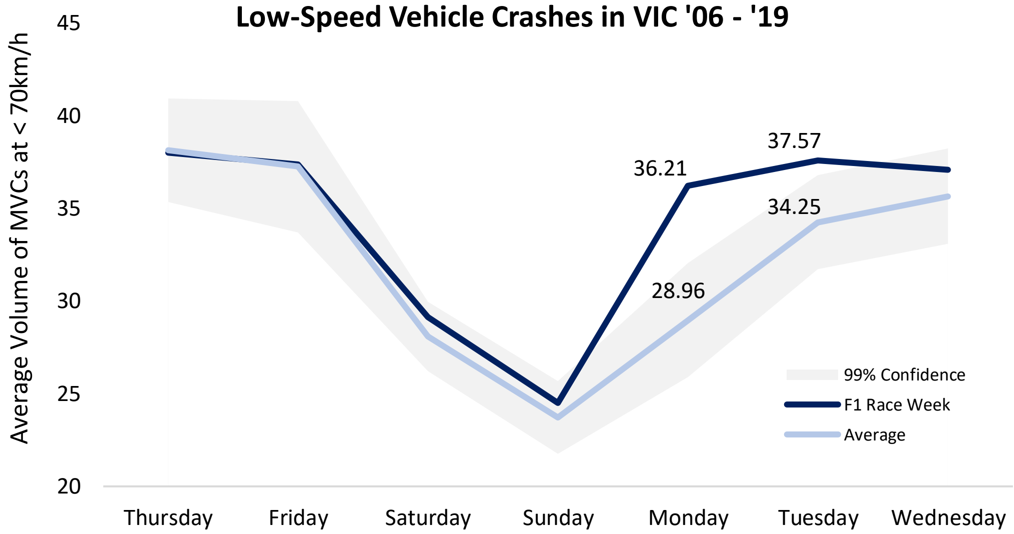
Day of Week	Average Difference	Event Difference	Welch's t-Value	p-Value
Thursday	10.64	9.14	0.53	0.30
Friday	12.64	11.50	0.37	0.36
Saturday	11.42	12.29	-0.37	0.36
Sunday	9.04	10.92	-0.90	0.19
Monday	8.60	11.00	-0.93	0.18

Evidently, there is no significant result at even the 10% level in this analysis, contrary to hypothesis (2), and we fail to reject our null hypothesis that there is no difference in mean differences. Hence, it would seem counter-intuitive to support Turner & McClure (2003) in their stance on the role of driver characteristics in behaviour in this case. The question must be asked, why might hypothesis (2) not hold? One possible answer is the changing demographic of motorsport viewership since Turner & McClure's study based on evidence prior to 2003. According to recent data released by the Formula One, approximately 20% of the online conversation surrounding the Formula One is now driven by women (Serra, 2022), a number which has grown substantially in the last decade.

Hence, this finding does not necessarily contradict the narrative that the Australian Formula One Grand Prix is related with greater road accidents, but rather suggests that over the course of time men and women alike could have become increasingly similar in their susceptibility to changes in driving behaviour.

Having found no apparent significance in the role of driver characteristics in this dataset, we can instead explore speed as a contributor to the general uplift in MVCs over the course of the Event in Victoria. Research conducted by Roden-Foreman et al. (2019) and Fischer et al. (1986) suggests that high-speed driving behaviour in particular is influenced by the exposure to motorsport entertainment. In fact, Roden-Foreman et al. argue that only incidents in which speed is a factor should be considered in addressing this research question (Roden-Foreman et al., 2019). In addition, Bannerman contends that an influx in low-speed crashes over the course of the Event is driven by Event infrastructure which confuses drivers in the Albert Park area (Bannerman, 2000). Clearly, then, we would anticipate two different responses in driver behaviour between these two groups. Hence, utilising ‘low-speed’ and ‘high-speed’ categorisations discussed in part V, we can again construct visualisations with benchmark data confidence intervals and discuss these effects. Note, in order to visualise the return to normality following the Event, we extend the weekly profile visualisation to Wednesday.

Fig. 5.1
Low-Speed Vehicle Crashes in VIC '06 - '19



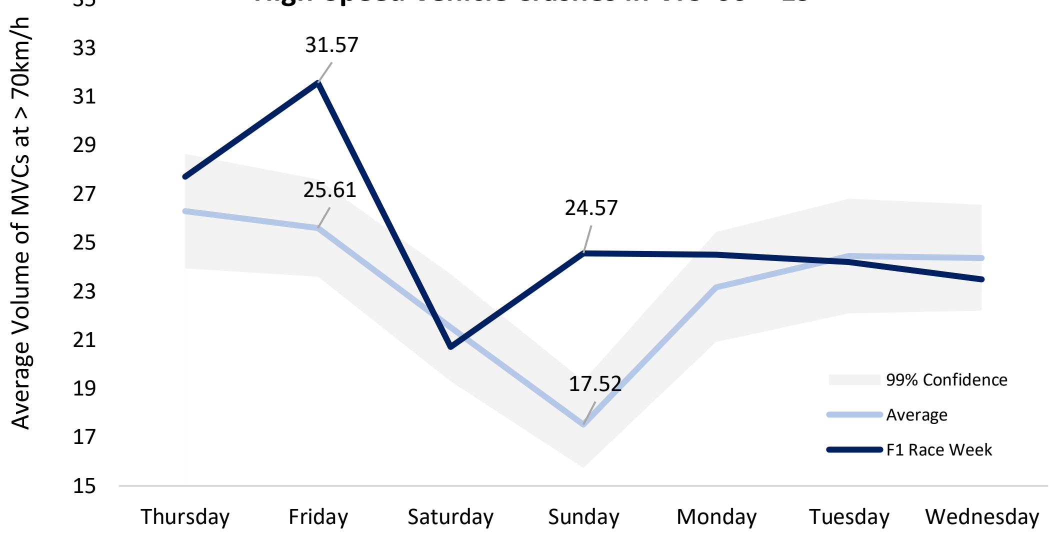


Fig. 5.2
High-Speed Vehicle Crashes in VIC '06 - '19

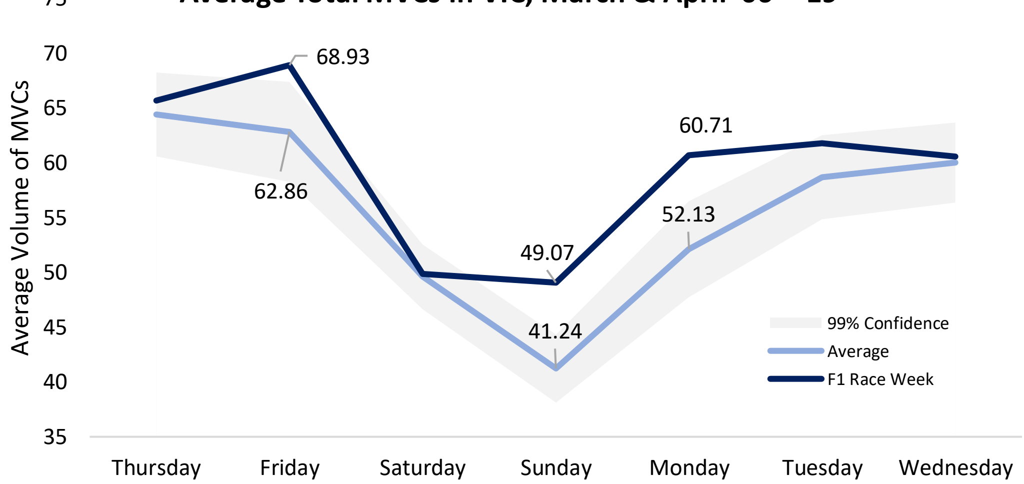


Fig. 5.3
Average Total MVCs in VIC, March & April '06 - '19

As shown in **Fig. 5.1** and **Fig. 5.2**, there are obvious differences in the profile of high-speed and low-speed MVCs over the course of the Event in Victoria. Low-speed MVCs are seemingly unimpacted across the four-day Event, while high-speed MVCs experience two noticeable peaks in volume on Friday and Sunday, far beyond the 99% confidence range. By contrast, low-speed crashes seem to experience uplift in the days following the Event, while high-speed crashes return to normal levels within the 99% confidence band immediately after the Event. Breaking data down by speed allows us to identify these two clear effects; an immediate uplift in high-speed crashes during the Event, and a gradual surge in low-speed crashes in the days following. Together, these two effects additively create abnormalities in **Fig. 3**, driving uplift beyond the 99% confidence range on Friday, Sunday, and Monday. Hence, in returning to hypothesis (1), while there is statistical evidence to point towards an increase in total MVCs over the course of the Event, the underlying effect we wish to identify is the influx in high-speed MVCs, as proposed by Roden-Foreman et al. (2019). Not only is the evidence directly coinciding with the Event more compelling, but it is more closely aligned with the previously established academic literature we wish to explore in this report. That being said, it is recommended that this gradual surge in low-speed crashes is investigated further.

The uplift in low-speed crashes observed in **Fig. 5.1** is consistent with the findings of Bannerman (2000), who argued that infrastructure surround the Albert Park track drove greater confusion and uncertainty among local drivers. The application of this idea is limited by our dataset; without access to geographical data we cannot infer whether or not the subsequent surge in low-speed MVCs is related to driver confusion. We would anticipate lower-speed crashes to be far more likely to occur in urban areas, and hence, they would be more vulnerable to this effect than high-speed crashes, typically associated with high-speed roads outside of built-up areas. Another explanation may simply be related to the sample size of the Event dataset, with only 14 Formula One events to inform the trend. This smaller sample will inherently be vulnerable to abnormality in weather conditions driving monthly seasonality.

Intuitively, one would imagine that high-speed and low-speed traffic would be equally responsive to changes in weather conditions. Roden-Foreman et al. focus purely on high-speed crashes in their NASCAR analysis, under the assumption that low-speed crashes which make up the vast majority of the dataset should not be influenced by reckless driving following motorsport entertainment (Roden-Foreman et al., 2019). By contrast, we will utilise low-speed crashes as a further control for omitted variables in analysing high-speed crashes. Hence, we again utilise Welch's T-Test to test for significance in high-speed MVCs, by conducting a difference-in-differences test between mean high-speed and low-speed MVCs over the benchmark and Event weeks. Here, low-speed crash data should control for omitted variables such as weather fluctuations and changes in traffic volume. Our null hypothesis in this case, is that the difference between the number of high-speed and low-speed MVCs does not change from the average difference over the course of the Event.

Fig. 5.4 Low-Speed vs. High-Speed Difference-in-Differences Test

(*=1%, **=5%, *=10%)**

Day of Week	Benchmark Difference	Event Difference	Welch's t-Value	p-Value	Absolute Uplift
Thursday	11.83	10.29	0.51	0.31	+1.41
Friday	11.64	5.79	1.41*	0.09*	+5.96
Saturday	6.58	8.43	-0.66	0.26	-0.8
Sunday	6.19	-0.07	**2.53****	**0.01****	**+7.05**
Monday	5.80	11.71	-1.54*	0.07*	+1.33
Tuesday	9.80	13.36	-1.45*	0.08*	-0.24
Wednesday	11.27	13.57	-0.87	0.20	-0.88

This analysis presents a particular interesting result; only Sunday, the day of the Grand Prix itself, has a statistically significant result at the 5% level for the difference-in-differences between low-speed and high-speed MVCs over the Event, relative to the benchmark. In essence, this would imply that, bluntly controlling for average state-wide weather conditions and traffic volumes, there is a statistically significant increase in high-speed motor vehicle crashes on the main race day of the Formula One Australian Grand Prix. We have sufficient evidence to reject the null hypothesis for only Sunday at the 5% level. At the 10% level, we would additionally reject our null for Friday, Monday and Tuesday. As shown in **Fig. 2.**, this uplift in absolute terms is equivalent to **+7.05** high-speed MVCs on the Sunday of the Event, relative to the benchmark average. This is a more conservative approach than purely testing for significance between the benchmark average and the Event, as it assumes that the uplift in low-speed crashes should not be attributed to changes in driver behaviour. One limitation of such an approach is, again, a lack of geographical insight. After all, we cannot infer whether the low-speed and high-speed crashes are susceptible to the same weather conditions, or level of traffic, by way of geographical proximity.

As an alternative test, we can purely focus on high-speed accidents relative to the benchmark, as was the approach of Roden-Foreman et al., under the assumption that lower-speed incidents are not impacted by the demonstration effect and our seasonality controls are sufficient in handling omitted variables. The null hypothesis we test in this case is that the average number of high-speed MVCs over the course of the Event is not different from the benchmark mean.

Fig. 5.5 High-Speed MVCs, Race Week vs. Benchmark

(*=1%, **=5%, *=10%)**

Day of Week	Benchmark Mean	Event Mean	Welch's t-Value	p-Value	Absolute Uplift
Thursday	26.30	27.71	-0.64	0.26	+1.41
Friday	25.61	31.57	**-2.43****	**0.02****	**+5.96**
Saturday	21.51	20.71	0.35	0.37	-0.8
Sunday	17.52	24.57	**-3.29*****	**0.00*****	**+7.05**
Monday	23.17	24.50	-0.56	0.29	+1.33
Tuesday	24.45	24.21	0.13	0.45	-0.24
Wednesday	24.38	23.50	0.43	0.34	-0.88

As shown in **Fig. 5.5**, analysing high-speed MVCs against the benchmark gives noticeable uplift on Friday and Sunday, both of which are statistically significant at the 5% level. This is, as expected, a less conservative estimate of high-speed MVC uplift over the course of the Event relative to the difference-in-differences approach. Together, these two tests provide evidence to support hypothesis (3), that there is an increase in higher-speed car crashes coinciding with the Event, supporting the narrative presented that viewers' driving behaviour imitates that demonstrated by Formula One drivers. In absolute terms, this analysis implies an uplift of **+13.01** high-speed motor vehicle crashes in Victoria over the course of the Australian Formula One Grand Prix. Together with our earlier analysis, this gives an estimated uplift range of between **+7.05** to **+13.01** additional high-speed motor vehicle crashes with the Event being held in Victoria.

7. *Outcomes*

Having calculated an estimated uplift range in high-speed MVCs in part VI, we can now undertake calculations to estimate the average impact of these crashes on the state of Victoria. As discussed in part VI, we choose to focus on high-speed MVCs as the most relevant and compelling narrative presented by existing academic literature. Following the methodology outlined in part V, the first step in identifying the associated burden on the state of Victoria is to apply parameters supplied by the ATAP guidelines for the human capital cost of MVCs in Victoria.

Fig. 6.1 Cost of MVCs by Speed & Severity (ATAP, 2010)

Cost Per Person	Fatal Injury	Severe Injury	Minor Injury	No Injury
70 km/h	$ 1,252,194	$ 253,929	$ 24,550	$ 0
80 km/h	$ 1,000,080	$ 278,378	$ 25,384	$ 0
90 km/h	$ 1,640,421	$ 295,238	$ 21,017	$ 0
100 km/h	$ 1,152,344	$ 357,459	$ 26,217	$ 0
110 km/h	$ 851,010	$ 375,091	$ 26,217	$ 0

These values in **Fig. 6.1** act as a starting point for calculating the weighted average cost per person involved in a high-speed MVC. Further, we utilise the formula presented in part V, however we focus solely on high-speed crashes where $x \geq 70$.

Fig. 6.2 Frequency of MVCs by Speed & Severity

MVC Frequency	Fatal Injury	Severe Injury	Minor Injury	No Injury
70 km/h	1	80	173	287
80 km/h	6	123	323	467
90 km/h	0	3	4	6
100 km/h	16	209	323	272
110 km/h	2	14	23	29

Fig. 6.3 Average Passengers Per MVC by Speed & Severity

Average Passengers Per Crash	Fatal Injury	Severe Injury	Minor Injury	No Injury
70 km/h	2.00	2.65	2.80	3.52
80 km/h	2.00	2.64	2.98	3.73
90 km/h	-	2.67	3.25	3.33
100 km/h	2.31	2.22	2.39	3.79
110 km/h	2.50	2.21	2.48	3.93

$$w_{High-Speed} = \frac{\sum_{x,s}(f(x,s) \times \ c_{x,s} \times p_{x,s})}{n}$$

By multiplying human capital cost parameters ($c_{x,s}$) (**Fig. 6.1**) by the frequency of each type of crash over the Event ($f(x,s)$), categorised by speed (x) and severity (s) (**Fig. 6.2**), and by the average number of passengers involved ($p_{x,s}$) (**Fig. 6.3**), we can calculate the total cost to Victoria over the course of our 14 Event samples. We do not utilise a single average passengers per crash value as there is clear discrepancy in passenger numbers across different categorisations, shown in **Fig. 6.3**. Dividing our total cost to Victoria over the Event sample by the sample size itself, n, we can find the weighted average total cost per high-speed crash based on historic Event data, $w_{High-Speed}$.

Through this process we calculate the weighted average total human capital cost per high-speed crash to be **AUD $188,149.01**. As discussed in part IV, this approach accounts for human, vehicle, and general costs. With this historic value, we can therefore imply that the marginal burden to the Victorian economy as a whole from an uplift in motor vehicle crashes would be equivalent to the absolute uplift multiplied by $188,149.01. In this case, with an expected absolute uplift in high-speed MVCs over the course of the Event of **+7.05** to **+13.01** as calculated in part VI, we would anticipate a marginal human capital cost of between **$1,326,450.52** and **$2,447,818.62** from hosting the Australian Formula One Grand Prix in Victoria. Given that the total benefit to the state of Victoria's Gross State Product from hosting the Event has been estimated between $32.04m and $39.34m (EY, 2011), these values would reduce the total benefit of the Event by

3.4% to **6.3%**. Evidently, in addressing the research question, ‘do economic impact assessments of Australian motorsport events overlook a societal cost from changes in driver behaviour?’, this analysis supports an affirmative answer.

The recommendations as a result of this outcome can largely be separated into two parts; improving the accuracy of economic impact assessments, and dedicating state resources to protect Victorians. First and foremost, it is evident that economic impact assessments should consider the relationship between motorsport events such as the Australian Formula One Grand Prix and greater high-speed motor vehicle crashes. By very definition, economic impact assessments are a formalised analysis of the marginal economic impact of an investment decision within a regional economy. A truly reflective analysis of the decision to host the Australian Formula One Grand Prix on a yearly basis should therefore contain the expected marginal human capital cost to Victoria of **$1,326,450.52** to **$2,447,818.62**. This report has demonstrated that publicly accessible data provided by VicRoads is adequate in quantifying the impact of hosting a motorsport event on the volume of MVCs. Moreover, the use of ATAP Guidelines can allow for a dollar value to be placed on the human capital cost to the state of Victoria. Hence, a similar process could indeed be followed for other economic impact assessments of major motorsport events conducted across Australia with reasonable simplicity.

By extension, with an anticipated increase in high-speed motor vehicle crashes of **+7.05** to **+13.01**, it would seem intuitive to deploy a greater police presence on public roads over the course of the Australian Formula One Grand Prix event. Research has shown that a random police presence on average reduces the volume of MVCs by 32% in a given area (Leggett, 1997). Further, it may be worthwhile in exploring the potential for a double demerit point weekend, with the system having been linked to an 11% decrease in MVCs in Western Australia (Watson et al., 2012). In the absence of greater geographical insight under the current dataset, the temptation would be to recommend police prioritise areas prone to high-speed driving activity (see Fredline et al., 2008). However, our analysis of driver characteristics in hypothesis (2) would suggest that academic literature surrounding the Event has overestimated the so-called “hoon effect” (see Fredline et al., 2008 and Fischer et al., 1986). We infer in this case that the authors largely refer to young men when categorising drivers as 'hoons' (see Armstrong & Steinhardt, 2006 and Palk et al., 2011). Interestingly, with no significant difference in the behavioural response of men and women, the notion that young men alone are responsible for elevated high-speed MVCs over the Event cannot be supported. Hence, areas traditionally associated with reckless driving behaviour may not be impacted to a greater extent than other regions. Although an elevated police presence might be recommended on public roads on both the Friday and Sunday of the Event, without geographical insight we cannot directly infer where best to allocate resources. Further analysis is also required regarding the cost-benefit trade-off of implementing a greater police presence. After all, the question must be asked, is the additional cost of greater police resourcing offset by a larger reduction in economic burden from less MVCs?

8. Limitations

While this analysis provides evidence of a relationship between elevated motor vehicle crashes and the Australian Formula One Grand Prix (or other motorsport by extension), it cannot imply causality. This is due to the fact that the analysis conducted in this report is largely retrospective. In essence, though we can assume that an undefined portion of Victorian drivers will have been exposed to motorsport entertainment, we cannot directly infer whether those involved in crashes spectated the Event. In fact, even if we could confirm that they did, we also cannot be sure that any reckless driving behaviour in particular was observed and acknowledged. Unfortunately, this is a key limitation of the methodology adopted in this research project and is unavoidable given our reliance on police reports of those involved in crashes. By continuation, we also do not account for the audience size or geographical location of MVCs. As discussed in part VI, access to geographical inference would allow for far greater nuance in analysis, particularly in controlling for omitted variables such as weather conditions and traffic volume.

Even if we are to assume a causal relationship holds between the Event and greater high-speed MVCs, we cannot necessarily be sure that the behavioural narrative behind the demonstration effect is responsible. In fact, any number of omitted variables could be to blame, such as abnormal weather conditions or alcohol consumption. In discussing driving behaviour following exposure to the

Formula One in particular we must note the significance of alcohol consumption and alcohol-related advertising content surrounding the sport. Academic literature has long since recognised the tendency of brewing companies to target motorsport sponsorships, conditioning spectators to “actively but unobtrusively associate beers, car and speed” (Buchanan & Lev, 1989). Heineken and Johnnie Walker branding, for instance, was discovered to be prominent in 41% of advertising breaks and 39% of race footage in the 2016 Formula One Season (Barker et al., 2018). Hence, it is recommended that future research, with greater access to classified components of police report data, could improve on this analysis and remove potential omitted variable bias by accounting for crashes in which alcohol consumption was deemed to be a relevant factor.

That said, this report does not necessarily need to prove causality to carry merit. After all, regardless of whether the uplift in high-speed MVCs over the course of the Event is indeed driven by behavioural factors or otherwise, the additional human capital cost calculated is still expected to be incurred by the Victorian economy. Alcohol may indeed be the true underlying causal influence; that does not change the need for the cost calculated in part VII to be included in future economic impact assessments. In short, while the underlying narrative is open to interpretation, the analytical results are far less malleable.

A criticism often levelled against economic impact assessments more broadly relates to the treatment of the true counterfactual. Indeed, a similar criticism can be made of this report. While the analysis conducted in this report assesses the uplift in high-speed MVCs with Victoria hosting the Event relative to Victoria without the Event, it does not consider any uplift in high-speed MVCs associated with the ‘next-best investment’ of the Victorian Government. For instance, should Victoria lose the rights to the Australian Formula One Grand Prix, the state government would likely invest in the next best alternative forgone. This investment should be treated as the true counterfactual, rather than a world in which no investment is made at all (see EY, 2011). While this would in essence double the scope of economic impact assessments by requiring a similar assessment to be completed for the next-best alternative investment option, it is a key limitation of this analysis worth bearing in mind. After all, if we are to attribute a portion of the uplift in MVCs to alcohol consumption, we might anticipate witnessing a similar effect from the alternative event in which the Victorian Government would choose to invest. If that is indeed the case, our marginal human capital cost would be far less substantial.

A final limitation of this report is the assumption that the entirety of the uplift in MVCs is contained within Victorian borders. While Victoria may host the Event, over 800,000 individuals across Australia are estimated to watch the Grand Prix itself via television (Perry, 2022). We would anticipate that the relationship between motorsport and an uplift in MVCs would lead to greater reckless driving behaviour in other states as the economic cost spills over beyond Victorian state borders. Moreover, under EY's 2011 assumption that one counterfactual scenario is the Australian Formula One Grand Prix event being hosted in another state of Australia, might we anticipate the reverse spill over effect into Victoria in this scenario? Evidently, further research may wish to utilise data which highlights the impact across the nation more broadly.

9. Conclusion

This research project intended to identify the relationship between motorsport events and spectators' driving behaviour by conducting an analysis of the Australian Formula One Grand Prix. First and foremost, this report presents evidence to support the notion that the Australian Formula One Grand Prix has historically coincided with a statistically significant increase in the volume of motor vehicle crashes. In reinforcing ideas presented by Roden-Foreman et al. (2019) and Fischer et al. (1986), this report recognises a significant influx in high-speed motor vehicle crashes in particular. Meanwhile, this analysis finds no evidence to support the notion that men are more likely to change driving behaviour than women throughout the duration of the Australian Formula One Grand Prix event.

As a contribution to the academic literature, this analysis presents valuable evidence to support the research of Fischer et al. (1986) and Roden-Foreman et al. (2019). These reports, although compelling, are limited by their datedness and lack of granularity, respectively. This report reinforces narratives presented by these authors by providing evidence that is both recent and granular. That said, as discussed in part VIII, this analysis would still benefit from access to geographical insight and an improved understanding of the influence of omitted variables such as alcohol consumption. Undoubtedly, the key to successfully addressing this research question is in the strength of the dataset. In absolute terms, we infer that there are is on average between **+7.05** and **+13.01** more estimated high-speed motor vehicle crashes when Victoria hosts the Australian Formula One Grand prix, relative to when it does not. From a cost perspective, this translates into a marginal human capital cost to the Victorian economy of between **$1,326,450.52** and **$2,447,818.62**. These are significant cost considerations and should undoubtedly be considered by commissioned third-parties responsible for conducting economic impact assessments for both the F1 and other Australian motorsport events. After all, these costs would reduce the calculated annual relative net increase in Victorian GSP (estimated between $32m and $39m in 2011 by Ernst & Young) by approximately **3.4%** to **6.3%**. In undertaking this analysis, we not only improve the accuracy of future economic impact assessments of the Australian Formula One Grand Prix, but we also add a string to the bow of third parties responsible for conducting analyses of motorsport events more broadly.

References

Anderson, C. A. (2002). PSYCHOLOGY: The Effects of Media Violence on Society. *Science*, *295*(5564), 2377–2379. https://doi.org/10.1126/science.1070765

Anderson, C. A., & Dill, K. E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology*, *78*(4), 772–790. https://doi.org/10.1037/0022-3514.78.4.772

Armstrong, K., & Steinhardt, D. (2006). Understanding street racing and "hoon" culture: An exploratory investigation of perceptions and experiences. *Journal of the Australasian College of Road Safety*, *17*(1), 38–44. https://eprints.qut.edu.au/2785/

ATAP. (2010). *4. Crash costs*. Australian Transport Assessment and Planning. https://www.atap.gov.au/parameter-values/road-transport/4-crash-costs

Australian Grand Prix Corporation. (2019). 2019 Annual Report. In *grandprix.com.au*. https://lp.grandprix.com.au/rs/014-JWG-984/images/AGPC_Annual_Report_Combined_2019.pdf

Bannerman, G. (2000). *Racetrack in the park : success or failure? : an accident analysis of the realigned public roads in Albert Park Reserve, May 1985 - December 1999*. Save Albert Park.

Barker, A. B., Britton, J., Grant-Braham, B., & Murray, R. L. (2018). Alcohol audio-visual content in formula 1 television broadcasting. *BMC Public Health*, *18*(1). https://doi.org/10.1186/s12889-018-6068-3

Brittle, C. (2022, April 12). *Australian GP records highest attendance ever in Melbourne*. SportsPro. https://www.sportspromedia.com/news/australian-gp-f1-attendance-melbourne-albert-park-adelaide-austin/

Buchanan, D. R., & Lev, J. (1989). Beer and Fast Cars: How Brewers Target Blue-collar Youth through Motor Sport Sponsorships. In *ERIC*. AAA Foundation for Traffic Safety. https://eric.ed.gov/?id=ED333299

Butler, G. (2022, April 10). *2022 Formula One Australian Grand Prix: Melbourne on-track schedule*. Drive. https://www.drive.com.au/news/2022-australian-f1-grand-prix-melbourne-on-track-schedule/

Department of Transport. (2022). *Crash Stats - Data Extract* [Data set]. https://discover.data.vic.gov.au/dataset/crash-stats-data-extract/resource/392b88c0-f010-491f-ac92-531c293de2e9

EY. (2011). *The economic impact of the 2011 Formula 1 ™ Australian Grand Prix Tourism Victoria*. https://business.vic.gov.au/__data/assets/pdf_file/0010/1551898/The-economic-impact-of-the-2011-Formula-Grand-Prix.pdf

EY. (2022). *Economic Impact Assessment*. Www.ey.com. https://www.ey.com/en_pl/economic-analysis-team/economic-impact-assessment

Fischer, A., Hatch, J., & Paix, B. (1986). *Road accidents and the grand prix* (pp. 151–168). Centre for South Australian Economic Studies.

Fogarty, M. (2016, March 14). *Victoria didn't steal Formula One grand prix, claims Jeff Kennett*. The Sydney Morning Herald. https://www.smh.com.au/sport/motorsport/victoria-didnt-steal-formula-one-grand-prix-claims-jeff-kennett-20160314-gniq57.html

Fredline, L., Jones, I., Shipway, R., Fletcher, J., Ladkin, A., Higham, J. E. S., Hinch, T., Fyall, A., & Barker, M. (2008). *Sport tourism and sustainability : inter-relationships, impacts and issues*. Channel View Publication Ltd.

Grand Prix. (2022). *Record numbers at the Formula 1® Heineken® Australian Grand Prix 2022*. Formula 1® Australian Grand Prix. https://www.grandprix.com.au/fan-zone/news/record-numbers-at-the-formula-1-heineken-australian-grand-prix-2022

Kasimati, E. (2006). Macroeconomic and Financial Analysis of Mega-Events: Evidence from Greece. *IOC Library*.

Keay, K., & Simmonds, I. (2005). The association of rainfall and other weather variables with road traffic volume in Melbourne, Australia. *Accident Analysis & Prevention*, *37*(1), 109–124. https://doi.org/10.1016/j.aap.2004.07.005

Leggett, L. (1997). Using police enforcement to prevent road crashes: The randomised scheduled management system. Policing for Prevention: Reducing Crime, Public Intoxication and Injury. *Crime Prevention Studies*, *7*, 175–197.

Morgan, S. E., Movius, L., & Cody, M. J. (2009). The Power of Narratives: The Effect of Entertainment Television Organ Donation Storylines on the Attitudes, Knowledge, and Behaviors of Donors and Nondonors. *Journal of Communication*, *59*(1), 135–151. https://doi.org/10.1111/j.1460-2466.2008.01408.x

Palk, G., Freeman, J., Kee, A. G., Steinhardt, D., & Davey, J. (2011). The prevalence and characteristics of self-reported dangerous driving behaviours among a young cohort. *Transportation Research Part F: Traffic Psychology and Behaviour*, *14*(2), 147–154. https://doi.org/10.1016/j.trf.2010.11.004

Perry, K. (2022, April 11). *RATINGS | Australians lapped up the action of the FORMULA ONE AUSTRALIAN GRAND PRIX*. TV Blackbox. https://tvblackbox.com.au/page/2022/04/11/ratings-australians-lapped-up-the-action-of-the-formula-one-australian-grand-prix/

Roden-Foreman, J. W., Foreman, M. L., Funk, G. A., & Powers, M. B. (2019). Driver see, driver crash: Associations between televised stock car races' audience size and the incidence of speed-related motor vehicle collisions in the United States. *Baylor University Medical Center Proceedings*, *32*(1), 37–42. https://doi.org/10.1080/08998280.2018.1512275

Scandizzo, P. L., & Pierleoni, M. R. (2017). ASSESSING THE OLYMPIC GAMES: THE ECONOMIC IMPACT AND BEYOND. *Journal of Economic Surveys*, *32*(3), 649–682. https://doi.org/10.1111/joes.12213

Serra, C. (2022). *The Netflix Effect: How an F1 Docuseries Set Off a Meteoric Rise in Popularity in the US*. Resources.audiense.com. https://resources.audiense.com/blog/the-netflix-effect-how-an-f1-docuseries-set-off-a-meteoric-rise-in-popularity-in-the-us

Smith, K. (1982). How seasonal and weather conditions influence road accidents in Glasgow. *Scottish Geographical Magazine*, *98*(2), 103–114. https://doi.org/10.1080/00369228208736523

TAC. (2001). *Wipe off 5*. Www.tac.vic.gov.au. https://www.tac.vic.gov.au/road-safety/statistics/summaries/speed-statistics/wipe-off-5

Tranter, P., & Warn, J. (2008). Relationships between interest in motor racing and driver attitudes and behaviour amongst mature drivers: An Australian case study. *Accident Analysis & Prevention*, *40*(5), 1683–1689. https://doi.org/10.1016/j.aap.2008.06.003

Tranter, P. J., & Lowes, M. D. (2005). The place of motorsport in public health: an Australian perspective. *Health & Place*, *11*(4), 379–391. https://doi.org/10.1016/j.healthplace.2004.07.004

Turner, C., & McClure, R. (2003). Age and gender differences in risk-taking behaviour as an explanation for high incidence of motor vehicle crashes as a driver in young males. *Injury Control and Safety Promotion*, *10*(3), 123–130. https://doi.org/10.1076/icsp.10.3.123.14560

Victoria, T. (2011). *FORMULA ONE AUSTRALIAN GRAND PRIX: BENEFITS TO VICTORIA*. https://business.vic.gov.au/__data/assets/pdf_file/0003/1551909/tourism_australian_grand_prix_report_2011.pdf

Watson, A. A. (2012). Editorial: Introductory remarks by Alan Watson. *The European Physical Journal Plus*, *127*(8). https://doi.org/10.1140/epjp/i2012-12099-5

Weiss, J. (2022, April 22). *How Much It Costs To Run A Formula 1 Race*. DMARGE. https://www.dmarge.com/2022/04/how-much-f1-costs.html

Yenier, Z., Vingilis, E., Wiesenthal, D. L., Mann, R. E., & Seeley, J. (2016). Relationships between thrill seeking, speeding attitudes, and driving violations among a sample of motorsports spectators and drivers. *Accident Analysis & Prevention*, *86*, 16–22. https://doi.org/10.1016/j.aap.2015.09.014