RBB | Economics

Annexure F: Response to the PHMI's Provisional Findings

Expenditure Analysis

RBB Economics, 15 October 2018

Executive Summary

The Private Healthcare Market Inquiry ("PHMI") released its Provisional Findings and Recommendations Report ("the PF") on 5 July 2018. Chapter 6 of the PF focuses on facilities in the private healthcare market, including hospitals, clinics, and other treatment establishments. As part of this chapter, the PF presents an assessment of healthcare expenditure attributed to private hospitals.[1] Prior to this, two preliminary versions of this analysis were also published by the PHMI. The first version was published in December 2016 ("the original attribution analysis"). Following submissions from stakeholders, a revised version was published in December 2017 ("the revised attribution analysis").

The purpose of this report is to comment on the expenditure analysis presented in the PF (and its accompanying annexures), focussing in particular on the conclusions that the PF seeks to draw directly from this analysis. RBB Economics LLP ("RBB") has previously commented on both of the PHMI's previous versions of the expenditure analysis, in the report of 26 July 2017 titled "RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data" ("the first RBB Report") and the report of 5 March 2018 titled "RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data" ("the second RBB Report").

We address three aspects of the PF's expenditure analysis, namely the cost attribution analysis, the assessment of cross-hospital and in-hospital expenditure patterns, and the historical overview of hospitals' price determination and price increases.[2] Where relevant, we have also sought to support our commentary with analyses conducted by RBB in the various PHMI data rooms.

Cost attribution analysis

The PF seeks to identify the part of the observed claims cost increases that cannot be attributed to changes in the explanatory variables that it has identified, by conducting a "cost attribution analysis". It does this by calculating the percentage increase in the predicted claims cost in each year and comparing this to the observed percentage increase in claims cost each year. After taking the difference between the two and attempting to control for inflation through the subtraction of CPI, the PF attributes the remaining portion of the observed increase to "unexplained factors".

The PF finds a significant portion of observed cost increases remains "unexplained". It attributes part of these unexplained increases to increasing utilisation over time (in the form of increases in admissions, average length of stay ("LoS") and level of care ("LoC)"), with the remainder attributed to *"other factors"*.[3] [4]

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1 The PF, paragraphs 311 to 396, page 224 to 240.

2 In addition to these analyses, the PF undertakes a study of the relationship between concentration and expenditure based on its cost attribution analysis. However, we address this aspect of the analysis in our discussion of supplier induced demand in the report titled "RBB Economics, Response to the PHMI's Provisional Findings: Supplier Induced Demand, 15 October 2018".

3 The PF, paragraph 322, page 227.

4 The PF, paragraph 345 to 346, page 232.

In respect of these “other factors”, while the PF notes that “*it is difficult to isolate the other factors accounting for the unexplained increase in in-hospital costs*”, the Facilities Annex to the PF states that this remainder is “*likely a result of price increases above CPI and/or increased numbers of line items per event*.”[5] [6] Therefore, the PF appears to suggest that some portion of the unexplained cost increase is attributable to market power and supplier-induced demand amongst hospital operators.

The PF elaborates on its interpretation of this remainder further in other chapters of its findings. Indeed, the PF draws from this analysis a number of strong conclusions with far-reaching consequences for participants in the private healthcare market. It is clear that “*[t]he HMI believes that these unexplained increases point to inappropriate drivers of claims costs*”.[7] Such “inappropriate drivers” are identified in the PF to include “*high year-on-year growth of in-hospital costs [signalling] market power of hospital groups”* and “*significant unexplained utilisation suggesting the prevalence of SID*”. [8] [9]

However, we find the PF’s approach to the cost attribution analysis to be fundamentally flawed, and hence its results and conclusions unreliable. This is because:

1. the analysis does not provide a sound basis for reaching the conclusions that the PF has sought to draw;
2. the analysis suffers from serious methodological flaws which prevent any meaningful conclusions being drawn from its results; and
3. a number of concerns around the PF’s models’ validity suggest that the models are very likely to suffer from bias which render its results inaccurate.

Our findings in each of these respects are as follows.

<u>Appropriacy of the analysis for informing the PF’s conclusions.</u> The attribution analysis appears to play an important role in shaping the PF’s conclusions on the existence of hospital market power and supplier-induced demand (described above). This is notwithstanding that the PHMI’s original intention was for the attribution analysis to provide **[CONFIDENTIAL]** only.[10]

Moreover, since the PF fails to define a threshold for intervention (i.e. a threshold above which any “unexplained” increase in claims costs would be deemed to provide robust evidence of a lack of competition in the private healthcare market), this implies that *any* unexplained claims cost increase can be considered cause for concern. This is evidently an unsustainable position, not only because any form of intervention has costs that must be weighed up against its anticipated benefits, but also because any statistical model will never predict outcomes perfectly.

5 The PF, paragraph 346, page 232.
6 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.
7 The PF, paragraph 134, page 334.
8 The PF, paragraph 177, page 197.
9 The PF, paragraph 261, page 217.
10 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 3.

Methodological flaws. While our report identifies a number of serious methodological flaws with the cost attribution analysis, the four most significant are as follows.

- First, the PHMI's insistence that its modelling approach is **[CONFIDENTIAL]**, cannot absolve it of having regard for standard econometric modelling practice for evaluating the drivers of a particular variable of interest and estimating the economic relationships between each of these drivers and that variable. In particular, it is critical that the PHMI correct for, and not simply acknowledge, the deficiencies it self-identifies, as well as those identified by stakeholders. This is not least because the PHMI's models *are*, in fact, being used to make predictions, and such predictions *are* being used to draw important conclusions about the effectiveness of competition in the private healthcare market.

- Second, the attribution analysis presented in the PF fails to have regard to the margins of error associated with its estimates which, as we demonstrate below, are substantial. Once one has regard to the margins of error associated with the PF's empirical results regarding the extent of annual cost increases that are "unexplained" then, even if these estimates are taken at face value (which is not appropriate for reasons discussed below), it becomes evident that the estimates do not provide a sound statistical basis to conclude that such unexplained increases were either material or consistently existed across the period analysed. Had the PF therefore defined a reasonable threshold above which unexplained cost increases would give rise to concern, it would be entirely possible that, when taking into account the margins of errors in its estimates, it would not be possible to reliably conclude that this threshold had been met.

- Third, the PF's calculation of the influence of "other factors" (through subtracting the unexplained percentage changes in the rate of admissions, length of stay and level of care from the unexplained changes in cost) is based on the unrealistic assumption that there is a linear relationship between these three variables and that of in-hospital costs. Notwithstanding that the PF's estimates of the effect of "other factors" are subject to the same margin of error issue discussed above, the implausibility of the assumption of a linear relationship in any event renders the PF's estimates of the cost increases that are attributed to "other factors" (which may include supplier-induced demand and market power) effectively meaningless.

- Fourth, while the PF benchmarks healthcare-specific inflation through the use of CPI, we understand that input cost inflation experienced by private hospitals has persistently exceeded CPI over the period covered by the PHMI's analysis, and by a material extent. This means that, notwithstanding the above, the "unexplained" portion of cost increases will be overstated when CPI is used to proxy for medical cost inflation. Where even small differences between CPI and actual medical cost inflation arise, this could result in any "unexplained" portion of cost increases being largely eliminated in each year. Once again, had the PHMI defined a reasonable threshold for intervention, it is highly likely that properly accounting for medical cost inflation could bring the unexplained cost increases below such a threshold.

Model validity issues. While the PF recognises the importance of testing its models' performance, the PF presents inappropriate diagnostic tests. These diagnostics are not conducive to testing whether its models suffer from bias – the most important test for a regression model to pass in order to yield reliable results. Moreover, the results of more insightful diagnostic tests strongly suggest that the PF's models are, indeed, biased. In particular, we find the relationships in the PF's models to be, *inter alia,* misspecified, subject to the omission of and mismeasurement of relevant variables and constructed from data that are not representative of the population.

Notably, the PF itself acknowledges that **[CONFIDENTIAL]**.[11] However, as explained above, the PF seeks to draw strong conclusions, regarding hospital market power and supplier-induced demand, from these unexplained components. Thus, on the contrary, these unexplained components **[CONFIDENTIAL]**, even if this was not the original intention, and since these components are affected by the omission of relevant variables, any inferences drawn from them will be unreliable. Moreover, **[CONFIDENTIAL]** the presence of omitted variable bias affects *all* the estimates and predictions made by its models, and thus the explained portions are biased too.

In conclusion, we identify a number of critical methodological flaws underpinning the PF's expenditure analysis, as well as serious modelling issues that strongly suggest the PF's models are biased. These render the results of the PF's cost attribution analysis both meaningless and unreliable, and thus an unsound basis for drawing any conclusions on the presence of market power and supplier-induced demand.

Analysis of expenditure patterns

The PF analyses expenditure patterns in two different ways. In particular, the PF compares the cost per admission for each hospital group over time and the development of in-hospital costs, specifically, across all hospital groups.

<u>Cost per admission by hospital group.</u> In its assessment of cost per admission by hospital group, the PF suggests that the three major hospital groups suffer from inefficiencies, which give rise to higher costs per admission at their facilities than at those of other hospitals. However, this is directly contradicted by evidence presented in the Facilities Annex to the PF which shows that these higher costs are largely explained by factors such as case mix (amongst other explanatory factors). Indeed, once such factors are controlled for, it is the NHN and other independent hospitals that are left with larger portions of their cost per admission increases that cannot be unexplained than is the case for the major hospital groups.

<u>In-hospital costs per admission.</u> In assessing trends in in-hospital costs, the PF asserts that theatre and ward fees account for the largest portion of in-hospital costs, and that these fees have been increasing. The PF argues that this is evidence of the fact that hospitals increased margins on ward and theatre fees to compensate for lower margins on surgical and consumables fees. However, the evidence used to substantiate this does not appear to support this conclusion, and much of the underlying data is noted by the PF itself to be unreliable. Moreover, data on fees cannot be used to draw inference on margins without

[11] PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 34.

accompanying cost data. The PF's claims of higher margins on theatre and ward fees are thus entirely unsubstantiated, and therefore as are its reliance on this as evidence of the existence of market power.

Price determination and price increases

The PF claims that although price increases have been within a reasonable range of CPI, present day price levels are still a concern since prices continue to reflect the coordinated approach to price determination prior to 2004. However, the PF's arguments regarding past and present day anticompetitive price levels are highly flawed. The PF does not provide any evidence to suggest that prices prior to 2004 were substantially above competitive levels (and itself acknowledges that this outcome may not have arisen). In particular, the PF fails to provide any kind of counterfactual as a reference for what competitive prices should have been.

Moreover, if the PHMI *had* conducted any comparative pricing assessment, there is no reason to expect that this would have revealed prices under the prior collective bargaining approach to tariff negotiations to be substantially above competitive levels. Indeed, the PF accedes that collective bargaining could yield efficient tariff outcomes. As a consequence, there is simply no basis for the PF's concern that current tariffs are above competitive levels.

The remainder of this report is structured as follows:

- in Section 1 we summarise the approach and findings of the PF in each of its three main lines of investigation;
- in Section 2 we address the PF's cost attribution analysis, focusing on aspects of the adopted methodology and on evidence the models' validity;
- in Section 3 we comment on the PF's analysis of expenditure patterns; and
- in Section 4 we consider the discussion around price determination and price increases presented in the PF.

1 The PF's Findings

1.1 Overview

The PF analyses expenditure in the private healthcare market, focusing in particular on hospital expenditure. The PF identifies two components that it considers are likely to be driving increases in expenditure, namely, utilisation increases and price/tariff increases. In order to explore these two components further, the PF pursues three independent lines of investigation:[12]

- a cost attribution analysis, which the PF uses to quantify the extent of the observed claims cost increases that cannot be attributed to changes in explanatory variables;
- an assessment of expenditure trends across different hospital groups and an assessment of in-hospital expenditure trends across all hospital groups; and
- a historical overview of hospitals' price determination and price increases.

In addition to these analyses, the PF undertakes a study of the relationship between concentration and expenditure based on its cost attribution analysis. However, we address this aspect of the analysis in the RBB report responding to the PHMI's provisional findings on supplier-induced demand.[13]

1.2 Cost attribution analysis

The PF seeks to identify the part of the observed claims cost increases that cannot be attributed to changes in the explanatory variables that it has identified, by conducting a "cost attribution analysis". It does this by calculating the percentage increase in the predicted claims cost in each year and comparing this to the observed percentage increase in claims cost each year. After taking the difference between the two and attempting to control for inflation through the subtraction of CPI, the PF seeks to attribute the remaining portion of the observed increase (i.e. the observed increase less the predicted increase less CPI) to "unexplained factors".

The PF's core approach to its attribution analyses is as follows:

- first, a model is specified using data for 2014. The parameter estimates obtained from this model are then used to predict medical claims cost per beneficiary in each year, and from this an average predicted cost per beneficiary per year is computed;
- second, using actual claims arising in the data, an average observed cost per beneficiary per year is computed;[14]
- third, annual percentage year-on-year changes in average predicted cost per beneficiary and average observed cost per beneficiary are calculated; and

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12 The PF, paragraphs 311 to 396, page 224 to 240.
13 RBB Economics, Response to the PHM's Provisional Findings: Supplier-Induced Demand, 15 October 2018.
14 Note that the term "observed" is used throughout this report to refer to actual costs arising in the claims data.

- finally, for each year-on-year change, the rate of inflation and the percentage change in the average predicted cost is subtracted from the average observed cost change, with the remaining increase referred to as the "unexplained cost increase" per beneficiary for each year.

The PF's approach to the cost attribution analysis does not appear to have changed materially since the revised attribution analysis released in December 2017. This is despite a number of submissions from stakeholders detailing serious methodological flaws with the analysis. Indeed, the only two substantial changes we were able to identify are:

- the rerunning of the analysis separately for day and overnight admissions. Here, the PF finds that there are some differences between the overall results and the results focussing only on day admissions, but that the results focussing on overnight submissions display similar trends to the overall results;[15] and
- the presentation of three alternative model specifications, which the PF contends have been undertaken as a robustness check of its model. The PF finds that although there are some differences in the results across specifications, the differences are small and the key trends identified remain the same.[16]

The PF concludes that beyond CPI, demographic and clinical factors account for a substantial portion of the increases in hospital expenditure. However, it finds a significant portion of observed cost increases remain "unexplained" by these factors.

In light of this, the PF then seeks to understand what is likely to be driving the remaining unexplained cost increases. It attributes part of these unexplained increases to increasing utilisation over time (in the form of increases in admissions, average LoS and LoC), with the remainder attributed to *"other factors"*. [17] [18]

In respect of these "other factors", while the PF notes that "*it is difficult to isolate the other factors accounting for the unexplained increase in in-hospital costs*", the Facilities Annex to the PF states that this remainder is "*likely a result of price increases above CPI and/or increased numbers of line items per event*."[19] [20] Therefore, although not explicitly stated (and at times partially contradicted), the PF appears to suggest that some portion of the unexplained cost increase is attributable to market power amongst hospital operators.

1.3 Analysis of expenditure patterns

In addition to the cost attribution analysis, the PF examines trends in hospital expenditures. These comprise:

1. a comparison of the trends in cost per admission across different hospital groups; and

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15 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.
16 CCHMI Technical Annexure to Expenditure Analysis Reports, July 2018, page 55.
17 The PF, paragraph 322, page 227.
18 The PF, paragraph 345 to 346, page 232.
19 The PF, paragraph 346, page 232.
20 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.

2. an assessment of the aggregate trends in in-hospital costs only across all groups, which the PF refers to as "direct hospital costs".

1.3.1 Trends in cost per admission across hospital groups

Comparing the total cost per admission of each hospital group separately, the PF finds that "*the three large groups have higher unadjusted costs per admission than NHN and the other independent hospitals"*.[21] The PF acknowledges that this finding may be driven by differences in case mix (i.e. that the three large hospital groups deal with more complex and therefore costly cases), but nevertheless suggests that this "*may not explain the difference completely*" and takes the view that *"higher unexplained costs per admission reflect some inefficiencies inherent in the system"*. [22]

1.3.2 In-hospital costs per admission

In assessing in-hospital costs per admission (i.e. excluding fees from specialists or attending service providers), the PF finds that, aside from a broad general category of "other" costs (including charges for gases, equipment, technology, and some NAPPI items where in-house codes are used), ward and theatre fees represent the largest component of in-hospital costs.[23] It also finds that ward and theatre fees are increasing at a faster rate than other cost categories.[24]

The PF argues that the higher rates at which it alleges theatre and ward fees are increasing (and/or their comparatively high absolute levels) may have stemmed from hospitals being no longer able to earn additional margins through rebates on surgical and consumables fees as of 2007/2008. In particular, the PF suggests that this change resulted in a "waterbed effect", whereby hospitals sought to increase the margins being earned on ward and theatre fees as a consequence of no longer being able to obtain such rebates.

The PF alleges that "*these margin transfers are … not reflective of real market prices*", and that the fact that hospitals were able to engage in this waterbed effect provides evidence of hospitals having market power.[25] It also then reasons that the fact that medical schemes did not seek to constrain this effect is indicative of their limited countervailing power over hospitals.

1.4 Price increases

Beyond the considerations described above, the PF also examines the role of price (i.e. tariffs) in the trend of increasing expenditure that it has observed. In this regard, the PF expresses three concerns with regards to current tariff pricing:[26]

- first, healthcare prices are "*inherently inefficient and derived from an anticompetitive, collusive base price*";

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21 The PF, paragraph 350, page 233.
22 The PF, paragraph 350, page 233.
23 The PF, paragraph 352, page 233.
24 The PF, paragraph 353, page 233.
25 The PF, paragraph 354, page 234.
26 The PF, paragraph 362. page 235.

- second, ward and theatre tariffs contain "*historical inefficiencies which have not been corrected for*"; and
- third, the persistence of fee-for-service ("FFS") as a model of pricing "*further entrenches inefficiencies in the system*".

With respect to the first concern, the PF finds that tariff increases appear to be only *"marginally"* above CPI over the period analysed.[27] However, notwithstanding this, the PF asserts that tariff levels remain a concern because, according to the PF, present day tariffs remain affected by anticompetitive pricing that existed prior to 2004.

This concern appears to stem from the fact that negotiations between hospitals and funders take place over tariff increases relative to the previous year, rather than over absolute tariff levels. Hence, the PF maintains the current tariffs continue to incorporate the effects of anticompetitive tariffs set prior to 2004, although the PF also acknowledges that *"there is no empirical evidence that the coordinated approach to tariff setting prior to 2004 resulted in higher than competitive tariffs*".[28]

With regard to the second concern, the PF refers specifically to observed upward adjustments in hospital ward and theatre tariffs post the removal of rebates on surgicals and consumables. Without further substantiation, it states that these increases "*appear to reflect market power and are therefore anticompetitive*".[29]

Finally, in terms of the third concern, through an analysis of hospital price trends, the PF finds the weighted average increase for FFS tariffs in 2014 was 6.9%, while the corresponding figure for ARM tariffs was 6.4%. The PF appears to consider that this difference implies that FFS tariffs are inefficient and expresses the concern that *"[t]he persistent reliance on FFS tariffs and the lack of meaningful diversion towards ARMS also exposes the inefficiency inherent in the hospital tariffs".*[30]

On the basis of these three concerns, the PF concludes that the current hospital tariff regime is indicative of hospital market power. Relatedly, it also concludes that medical schemes have been ineffective in constraining this market power.

In addition the PF cautions that the fact that recent hospital tariff increases have been modest (i.e. in line with inflation) does not mean that hospitals do not possess market power. This is presumably based on the reasoning set out above that the PF considers that current price levels are still based on the supra-competitive prices it alleges were in existence prior to 2004.

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27 The PF, paragraph 364, page 235.
28 The PF, paragraph 367, page 236.
29 The PF, paragraph 366, page 236.
30 The PF, paragraph 369, page 236.

2 Cost Attribution Analysis

2.1 Overview

As detailed in sub-section 1.2 above, the approach to the cost attribution analysis presented in the PF has not substantially changed since the revised attribution analysis released by the PHMI in December 2017. This approach therefore remains fundamentally flawed for the reasons set out previously in the first and second RBB Reports.

In particular, the analysis contains a number of significant methodological flaws. Each of these flaws, even when considered individually, mean that the PF's analysis cannot be used to provide any reliable indication of the extent by which costs (controlling for relevant explanatory factors) have increased due to market power and/or supplier-induced demand.

In addition, there are a number of issues that undermine the validity of the models presented in the PF. As a result, these models are unlikely to adequately and reliably capture the relationships between costs and the underlying factors that affect them, which means, in turn, that their predictions are likely to be invalid.

However, before we discuss the above in more detail, we first briefly comment on the role played by the attribution analysis in shaping the conclusions of the PF more generally.

2.2 Appropriacy of the analysis for informing the PF's conclusions

The September 2018 document titled "PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports" ("the Second Expenditure Analysis Response") states that **[CONFIDENTIAL]**.[31] As such, the Second Expenditure Analysis Response suggests that **[CONFIDENTIAL]**.[32]

However, this is inconsistent with the approach taken by the PF. Specifically, there are a number of instances where the PF draws on the results of the attribution analyses (and the "unexplained" increases and "other factors" in particular) as evidence in support of its main conclusions regarding hospital market power and supplier-induced demand. For instance:

- The PF finds that "*funders have been unable to prevent high year-on-year growth of in-hospital costs*", which serves as one of a number of "*clear signals that… market power of hospital groups … has had a significant impact on competitive dynamics*."[33]
- The PF refers to the expenditure analysis as a means to *"shed more light on…the influence of hospital market power on tariff levels."*[34]

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31 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 3.

32 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 3.

33 The PF, paragraph 177, page 197.

34 The PF, paragraph 310, page 223.

- The PF notes that the HMI "*found significant unexplained utilisation suggesting the prevalence of SID*". [35]
- The PF finds that "*Local hospitals across the groups may 'chase' for patients, beyond the level of efficient costs. These additional costs will be reflected in the so called 'residual/unexplained factors' in our expenditure analyses."* [36]
- The PF notes that "[*t]he HMI believes that these unexplained increases point to inappropriate drivers of claims costs since the factors already known to result in more ill-health… have already been taken into account*".[37]

The attribution analysis therefore appears to play an important role in shaping the PF's conclusions on the existence of hospital market power and supplier-induced demand. This is notwithstanding that the PHMI's original stated intention was for the attribution analysis to provide **[CONFIDENTIAL]** only.[38]

Relatedly, the PF does not define a threshold for intervention, i.e. a threshold above which any "unexplained" increase in claims costs would be deemed to provide robust evidence of a lack of competition in the private healthcare market, and therefore grounds for intervention. Had such a threshold been set out, this would have placed more focus on this key issue.

Moreover, the absence of such a threshold gives rise to the implication that *any* unexplained claims cost increase that is computed (i.e. any increase greater than zero) can be considered cause for concern and grounds for intervention. This is evidently an unsustainable position, not only because any form of intervention has costs that must be weighed up against its anticipated benefits, but also because any statistical model will never predict outcomes perfectly.

Indeed, as discussed in the second RBB Report, all models are based on samples of data, not the true population of interest, and are simplifications of reality. While steps can be taken to ensure the results from models are as accurate as possible, all resulting estimates are subject to a certain margin of error.[39]

2.3 Methodological flaws

In this sub-section, we discuss a number of methodological flaws with the PHMI's cost attribution analysis. Notably each flaw, individually, is enough to render the PHMI's results unreliable, such that it is not possible to draw any meaningful conclusions from this analysis. However, before doing so we first briefly discuss the position set out in the PF that any deficiencies that exist in its overall modelling approach do not in any way undermine the ability to draw conclusions from it.

[35] The PF, paragraph 261, page 217.
[36] The PF, paragraph 385, page 238.
[37] The PF, paragraph 134, page 334.
[38] PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 3.
[39] RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 4.

2.3.1 Overall modelling approach

The Second Expenditure Analysis Response notes **[CONFIDENTIAL]**.[40] Moreover, it explicitly acknowledges that **[CONFIDENTIAL]**.[41]

The above suggests that, the PHMI considers that **[CONFIDENTIAL]** from the perspective of evaluating whether the results of its attribution analysis are robust and reliable. In other words, it is absolved from having regard to or correcting for the deficiencies in its modelling approach simply because a pre-defined modelling approach that is used for certain types of assessment has been followed.

This line of reasoning is not only nonsensical, but avoids the fact that, contrary to what is contended, the PF's modelling approach does not align with standard modelling practice where the aim of the model is to evaluate the drivers of a particular variable of interest and estimate the economic relationships between each of these drivers and that variable (as is required if the model is then to be used to predict the variable of interest in other time periods).

On the contrary, any such modelling exercise should start by identifying, on the basis of economic intuition and industry knowledge, the full list of variables that are likely to determine the variable of interest. This will enable the model to avoid omitted variable bias, which is critical if the results of the model are to be relied upon for reasons set out in more detail in sub-section 2.4.3.2. Appropriate steps should also be taken to ensure that the nature of the relationships between the explanatory variables and the variable of interest are specified appropriately, and any material measurement error is avoided.

However, these considerations are largely absent from the PHMI's analysis, and in fact this is often expressly acknowledged. For instance, the PHMI acknowledges that **[CONFIDENTIAL]**.[42] This means, axiomatically that its models will suffer from omitted variable bias.

Moreover, while the PHMI seeks to excuse many of the flaws in its modelling approach by drawing a distinction between **[CONFIDENTIAL]**, this is simply incorrect. As explained in sub-section 1.2, the PHMI's models are all based on data for 2014, with the parameter estimates from these models then used, in combination with data from earlier years to yield predicted claims costs. This is the very definition of predictive modelling.

2.3.2 Margins of error

As noted above, any estimate is based on a sample and not the true population. This means that it carries with it a margin of error. This margin of error is reflected through the statistical confidence interval surrounding the estimate, which indicates the range of values between

40 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 34.

41 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 30.

42 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 34.

which the true value of the estimate can be said to lie with a given level of statistical certainty (e.g. 95%, which certainty is a commonly used level for this purpose).

Since any estimate carries with it a margin of error, it is inappropriate to draw conclusions from that estimate without having considered the degree of statistical certainty/confidence attached to it (as given by its confidence interval). Most obviously, if the margin of error surrounding a particular estimate is wide, then one can be considerably less confident in drawing conclusions from the value of the estimate than if the margin of error is narrow.

In addition, it is important to note that when a point estimate is itself computed from various point estimates that carry their own margins of error, there is a compounding effect such that the margin of error is significantly amplified. As such, it is particularly important to have regard for margins of error where this is the case.

That the attribution analysis presented in the PF fails to consider the margins of error associated with its estimates is therefore one of its most significant shortcomings. Moreover, as we demonstrate below, these margins of error are substantial, which accordingly has a significant impact on the implications that can reliably be drawn from the analysis.

In this sub-section we first discuss the implications of the existence of margins of error in more detail. We then set out the key figures in the PF's analysis that are subject to margins of error, and present our own estimates of the margins of error associated with the annual unexplained cost increases that the PF presents, before finally addressing certain responses that the PHMI has made in response to previous concerns raised.

2.3.2.1 Implications of failing to account for margins of error

As indicated above, the larger the margin of error, the less confidence one can place in the reported results closely reflecting the "true" figures, i.e. the figures for the whole population in reality. This is because a larger margin of error implies a wider range of values within which we can be reasonably sure that the “true” figure lies.

As such, it is standard statistical and econometric practice to construct a confidence interval around one's point estimates. This provides the range of values within which the true population value is likely to lie, with a given level of statistical confidence.

In short, the construction of a confidence interval allows one to conclude that the true population value lies somewhere between the upper and lower bounds of the confidence interval, with the selected level of statistical certainty. For instance, in the case of a 95% confidence interval, this means that we can be 95% confident that the true population value lies between the upper and lower bounds of the confidence interval.

As such, where true population values are not observable, and hence estimates must be computed, it is possible to use such estimates to construct confidence intervals that allow us examine the range of values that the true population value is likely to take. This, in turn, also allows us to evaluate whether the point estimate that has been calculated is likely to be close to the true population value or not. However, it is not possible to draw any further inferences from the point estimate itself, given that it carries with it a margin of error (by virtue of being an only an estimate).

In the context of the PHMI's analysis, we consider it to be of particular importance that the PHMI bear in mind the *lower bound* of any confidence interval surrounding its estimate of the unexplained cost increase. This is because the lower bound represents the figure with which one can have statistical certainty that the true population value is no lower than. In other words, if the lower bound of the confidence interval is x%, we can be statistically confident that the true value is at least x%.

Had the PHMI defined a reasonable threshold above which unexplained cost increases would give rise to concern (as discussed in sub-section 2.2 above), it is entirely possible that, when taking into account the margins of errors in its estimates, the lower bound of the unexplained cost increases computed could fall below this threshold. Were this to be the case it would indicate that there is not a statistically robust basis for intervention.

Consequently, by failing to examine or even report margins of error, the PHMI does not consider how statistically confident it can be when drawing conclusions from these results. This issue has been raised previously in both the first and second RBB Reports.[43] Further, as set out in the second RBB Report, the significance of this issue can be illustrated using two hypothetical examples.

Example 1

For the purposes of the first example, assume that an analysis based on a particular sample of claims yields a point estimate for the unexplained cost increase of 2%, with a corresponding 95% confidence interval of 1.9% to 2.1% (i.e. a relatively narrow confidence interval). Here, it can be said with 95% certainty that the unexplained cost increase is at least 1.9%. It can also be said with a high degree of statistical certainty that the true value in the population is within 0.1 percentage point of, and hence approximates to, 2% (given the narrow range of the confidence interval).

Example 2

In contrast, for the purposes of the second example, assume that an analysis of a particular sample of claims yields the same point estimate of 2%, but with a corresponding 95% confidence interval of 0.5% to 3.5%. Here the confidence interval is much broader, so that we can be considerably less certain that the true unexplained cost increase is approximately 2%. Indeed, we can only be 95% certain that the unexplained cost increase is at least 0.5% (unlike 1.9% in the previous example).

These two examples illustrate that analyses that yield identical point estimates may nevertheless give rise to materially different conclusions (and may thus have very different implications in respect of motivating for intervention). In particular, while the first example

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[43] See RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 8 to 10, and RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 9 to 13.

would allow us to reliably conclude that unexplained cost increases "are likely to be approximately of 2%", the second example would not allow for such a conclusion to be drawn. Rather, the second example would only allow for a more tentative conclusion, such as that unexplained costs increases "are likely to be greater than zero" or "are likely to be at least 0.5%".

2.3.2.2 Margins of error in the PF's analysis

As a starting point, it is important to appreciate that a number of the inputs used in computing the PF's annual unexplained increases, which are derived from the difference between the percentage change in average observed and predicted costs (less CPI), are estimates generated from a sample of data. These inputs therefore carry with them margins of error. In particular:

- average predicted costs for each year are accompanied by a margin of error, given that they are derived from numerous parameter estimates which have their own margins of error having been generated from a sample of data;
- average observed costs for each year are accompanied by a margin of error given that they are derived from a sample of claims collected by the PHMI;[44]
- annual percentage changes in average observed and predicted costs are each accompanied by a margin of error, given that the figures upon which they are based themselves carry margins of error. Moreover, these margins of error will be larger than the margins of error associated with the underlying averages for each year given that margins of error increase when calculations are based on figures that have their own margins of error; and
- the measure of CPI, used to account for inflation, is estimated by Statistics South Africa and therefore accompanied by a margin of error.[45]

Each of the above figures therefore involves its own margin of error, and since many are computed from other estimates that entail their own margins of error there is a compounding effect. This means, in turn, that the even if the margins of error associated with each individual estimate is small, the margins of error associated with the PF's estimates of annual unexplained increases may potentially be large (and as we demonstrate in more detail below they are large in practice).

2.3.2.3 Approximating the PF's margins of error

In order to relate the above to the case at hand, for the PF's cost per admission model (all schemes, broad disease burden), we have estimated a lower bound of the range of unexplained annual increases. These are derived from approximated confidence intervals

[44] In the event that the PHMI's dataset included the full universe of claims in the population, these figures would not be an estimate, but rather a true value for the average claim cost in the population. However, on account of the fact that the PHMI's dataset is missing scheme data in all years, it can only be considered to contain a sample of claims in the population and not the true claims population.

[45] The PF, paragraph 123, page 55.

computed using the PF's model's output in the data room.[46] Specifically, our approach was as follows:

- first, we computed the average predicted cost per admission per year using the PF's cost per admission model (all schemes, broad disease burden). Note that the results produced matched those set out in the PF;
- second, we computed the average observed cost per admission per year using the actual claims arising in the admissions data. Again, these results match those set out in the PF;
- third, we computed approximations of the 95% confidence intervals centred around these averages, with interval bounds constructed using the standard error of the average observed cost per admission each year (thus in both cases the measure of dispersion is based on the dispersion of actual costs);[47]
- then we computed an approximate lower bound for the observed cost increase each year, calculated as the difference between the lower bound of the observed cost confidence interval in year t+1 and the upper bound in year t;
- similarly, we computed an approximate upper bound for the predicted cost increase each year, calculated as the difference between the upper bound of the predicted cost confidence interval in year t+1 and the lower bound in year t; and
- finally, we compared the approximate upper bound predicted cost increase and approximate lower bound observed cost increase (less CPI) each year.

Following the above steps yields an estimate for the lower bound unexplained annual increase in each year.

The results of the computations described in the bullets above are presented in Annex A. Table 1 summarises our results from calculating the unexplained annual increases in cost per admission, and compares these figures to those contained in the PF. The first row presents our calculation of the lower bound of the range for the unexplained increase in which we can be 95% confident that the true value lies (according to the method described above). The second row sets out the PHMI's calculated unexplained annual increases (as presented in the PF's attribution analysis annexes), according to a comparison of the average observed increase and average predicted increase (after subtracting CPI) each year.[48]

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46 Note that these confidence intervals are approximated, since it was too complex to apply the strictly correct method for constructing these in the context of the data room. However, the figures calculated should provide a good indication of the relevant statistics. The strictly correct method for computing a prediction interval is described by Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.198 – 201.

47 Assuming a normal distribution, the confidence interval for the average observed cost per admission = (average observed cost per admission – 1.96 * standard error of the average observed cost per admission; average observed cost per admission + 1.96 * standard error of the average observed cost per admission). Similarly, the confidence interval for the average predicted cost per admission = (average predicted cost per admission – 1.96 * standard error of the average observed cost per admission; average predicted cost per admission + 1.96 * standard error of the average observed cost per admission). Standard errors on the basis of the dispersion of observed costs are used since measures of dispersion have to be calculated using actual costs arising in the data.

48 See Table 26 of CCHMI Expenditure Analysis Report 2: Overall Cost Trends and Attribution Analyses, July 2018, page 18.

Table 1: Unexplained increase in cost per admission (all schemes, broad disease burden) using confidence interval bounds vs. averages, 2011 to 2014

Unexplained cost per admission	2011	2012	2013	2014	Average
Approximate lower bound unexplained increase (%)	2.09%	1.29%	-0.51%	-0.17%	0.67%
Average unexplained increase (%)	3.40%	2.60%	0.80%	1.13%	1.98%

Source: CCHMI Expenditure Analysis Report 2: Overall Cost Trends and Attribution Analyses, July 2018, page 18, Table 26; RBB data room analysis.

As can be seen from the table, according to the PHMI the average unexplained increase over the period is 1.98%. In contrast, the average lower bound unexplained increase over the period is only 0.67%. That is, we can say with 95% certainty that the average unexplained increase over the period is no lower than 0.67% - it may be higher, but it is not possible to say whether it is higher, or by how much, with statistical confidence. It is also notable that the lower bound unexplained increase is negative in both 2013 and 2014, suggesting that in these years, one cannot say with 95% confidence that there is any positive unexplained increase.

The above illustrates that the unexplained increase that one can put forward with 95% certainty is much lower than that reported in the PF. In other words, even if the PF's empirical results regarding the extent of annual cost increases that are "unexplained" are taken at face value (which is not appropriate for reasons that we set out in detail below), they do not provide a sound statistical basis to conclude that such unexplained increases consistently exist across the period analysed, or that such unexplained increases were material across the period.

This highlights the importance that the PF bases its recommendations not on point estimates but on those figures with which it is possible to be statistically confident**.**

2.3.2.4 The PHMI's response to concerns raised

In the Second Expenditure Analysis Response, the PHMI has sought to address our previous submissions relating to margins of error.[49] [50] Therein, it accepts that **[CONFIDENTIAL]**.[51] The PHMI also asserts that, **[CONFIDENTIAL]**.

Concerning the first of these points, we certainly do not dispute that margins of error occur **[CONFIDENTIAL]**. Indeed, this is reflected in the fact that the lower bound of the confidence interval surrounding a point estimate takes a lower value than the point estimate itself, while the upper bound takes a higher value.

However, the PHMI fails to recognise that the concerns discussed above do not relate to the existence of margins of error *per se*, but rather what implications they have for the conclusions that can be drawn from particular point estimates. In particular, where a properly considered

49 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 35.

50 For completeness, the PHMI has previously justified not presenting margins of errors on account of the fact that statistical models produce estimates that are the "*most likely point in the statistical distribution*" (PHMI Response to Data Room Submissions, 8 December 2017, page 14). However, as we have explained, all that can be said with statistical certainty is that the true population value is within a given range. It is *not* possible to say that one particular point is appreciably more likely to be the true population value than any other within the confidence interval.

51 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 35.

threshold for intervention is identified, one must be satisfied that the point estimate exceeds this threshold with an acceptable degree of statistical confidence. This is especially so given that any form of intervention is costly, both in terms of direct costs but also unintended consequences.

Where the margin of error surrounding a particular point estimate is sufficiently large that the lower bound of the confidence interval surrounding it is below the intervention threshold, this means that one cannot conclude with statistical certainty that the true value lies above the threshold. Hence, in this situation there is not a statistically robust basis for intervention (since in reality there could be no basis for intervention at all).

By the same token, while the PHMI is correct in principle that **[CONFIDENTIAL]**, we have shown above that the differences between the PHMI's point estimates and their 95% confidence interval lower bounds are material. This arises because, as mentioned above, despite the large sample sizes used, the PHMI's computed unexplained cost increases are themselves based on estimates (and in some cases estimates based upon other estimates) that entail their own margins of error, giving rise to a compounding effect.

Accordingly, the PHMI's responses on the issue of margins of error in no way negate the importance of considering margins of error, or the fact that failing to do so is a significant methodological shortcoming. Moreover, as we have shown above, when these margins of error are computed, they indicate that it is not possible to reliably conclude that unexplained cost increases consistently exist across the period analysed, or that unexplained increases were material across the period.

2.3.3 Decomposition of unexplained cost increases

A second methodological issue with the PF's analysis concerns the decomposition of the unexplained in-hospital cost increases that it has estimated into sub-components. In particular, the analysis seeks to establish what portions of these unexplained cost increases are attributable to changes in admission rates, LoS and LoC, as distinct from "other" factors.

In order to do so, the PHMI uses the same set of control variables as employed in the total in-hospital costs model to model each of admission rates (i.e. admissions per 1000 lives), LoS, and LoC in 2014. The PF, much like its analysis of in-hospital costs, presents the contributions to annual increases in these outcomes attributable to the explanatory factors included in its models and unexplained factors.[52] [53]

The PHMI then takes the unexplained portion of in-hospital cost increases each year, and subtracts from this the unexplained portion of admission rate increases, the unexplained portion of LoS increases and the unexplained portion of LoC increases. This yields what the PF claims to be a remaining unexplained increase in in-hospital costs that is attributable to

52 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.

53 For completeness, control variables relevant to beneficiaries are used to model admission rates, while variables relevant to admissions are used to model length of stay and level of care.

"*other factors*". The Facilities Annex to the PF claims that "other factors" could be attributed to "*price increases above CPI and/or increased numbers of line items*".[54]

This analysis appears to play an important role in shaping the findings of the PF overall since the existence of a residual unexplained increase in-hospital costs due to "other factors" is used as evidence in support of the existence of hospital market power and supplier-induced demand. Specifically, as mentioned in sub-section 2.2 above, the PF finds that "*[l]ocal hospitals across the groups may 'chase' for patients, beyond the level of efficient costs... reflected in the so called 'residual/unexplained factors' in our expenditure analyses."* [55] Moreover, "*[t]he HMI believes that these unexplained increases point to inappropriate drivers of claims costs*".[56]

With regards to the PF's overall approach to decomposing unexplained cost increases, we agree that, if one were to take the PHMI's estimates of the portion of cost increases that are "unexplained" as given, a prudent next step would be to seek to understand the causes of these unexplained increases. However, the PF's approach in this regard is flawed.

In particular, the approach taken, i.e. to subtract from an unexplained percentage cost increase the unexplained percentage changes in the rate of admissions, LoS and LoC, essentially assumes that there is a linear relationship between these three variables and in-hospital costs. For example, it assumes that a 1% increase in admission rates necessarily translates into a 1% increase in in-hospital costs per beneficiary.

However, this assumption is highly unlikely to be correct given that, as we understand from LHC, more frequent admissions do not translate into higher costs in the same proportions. For instance, the increase in total in-hospital costs associated with a 1% increase in admissions is likely to differ materially depending on whether those admissions are medical or surgical. If the 1% increase in admissions were entirely attributable to medical admissions, the cost of these incremental admissions is likely to be materially below the cost of surgical admission types. As another example, consider LoC, which is measured by an assigned numeric "acuity factor" based on the ward tariffs associated with the admission. It is not apparent what is meant by a 1% increase in such a measurement, or that this should give rise to a 1% increase in costs.

The implication of this is that the remaining figure attributed to "other factors" is nonsensical, and incapable of providing a reliable indication of the unexplained increase in costs that may be as a consequence of market power and/or supplier-induced demand. Thus, even if one ignores the issues regarding margins of error set out in sub-section 2.3.2 above, the flaws in the PF's approach to decomposing unexplained cost increases renders its results unreliable and makes it impossible to draw any reliable inferences from these results.

As an aside, it should also be appreciated that, similar to the unexplained cost increases that have been estimated, this remaining unexplained portion attributed to "other factors" will also

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54 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.
55 The PF, paragraph 385, page 238.
56 The PF, paragraph 134, page 334.

have a margin of error surrounding it. Indeed, its margin of error will be *even larger* given that the "other factors" component is estimated from other estimates that entail their own margins of error, such that there is a compounding effect (see sub-section 2.3.2 above). Hence, like the unexplained cost increase estimates, taking into account the lower bound of the surrounding margin of error, it may not be possible to say with statistical confidence that the contribution of "other factors" to unexplained cost increases is above zero.

2.3.4 CPI as a benchmark for healthcare inflation

Even if one ignores the issues set out in the previous sub-sections, the PF's estimates of "unexplained" cost increases are rendered meaningless in light of the PHMI's use of CPI in its analysis. This is for two reasons.

First, CPI is likely to underestimate medical cost-specific inflation. As the first RBB Report explained, there is no reason to believe that CPI bears a close relationship to the actual costs of providing private healthcare services and, as a result, the PHMI does not adequately control for input cost inflation through the use of CPI.[57]

In this regard, the PF argues that *"given that wages and other income-contracts are based on CPI, any health inflation consistently above CPI inflation means that access to healthcare is becoming less affordable"*.[58] However, even if the PF were correct in respect of these two kinds of input costs, hospitals face a broad range of input costs beyond these two types of cost. Hence, this does not provide a sound basis to conclude that CPI is likely to mirror hospital input costs more generally.

In reality, it is likely that increases in hospital input costs will materially exceed CPI, as explained in the first RBB Report.[59] Specifically, LHC previously explained to the PHMI in its First Submission, dated 31 October 2014, that input cost inflation experienced by private hospitals has persistently exceeded CPI over the period covered by the PHMI's analysis, and by a material extent. For example, as discussed in the PF, hospital groups have explained that wage inflation is a key driver of hospital costs.[60] In particular, nursing costs account of the largest share of their wage bill, and nursing salary inflation has been above CPI. These claims are untested by the PHMI.[61]

As such, it is not unreasonable to expect in-hospital costs to rise at a faster rate than CPI, all else equal. This means, in turn, that the "unexplained" portion of cost increases will be overstated when CPI is used to take into account inflationary effects.[62]

In this regard, as the second RBB Report demonstrates, even small differences between CPI and actual medical cost inflation can translate into large differences in cost increases in monetary terms.[63] As an illustration of this, Table 2 below shows the contribution of

57 RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 7 to 8.
58 The PF, paragraph 128, page 56.
59 RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 7.
60 The PF, paragraph 319 1.1, page 225.
61 The PF, paragraph 319 1.2 – 319 1.3, page 225.
62 RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 8.
63 RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 22.

"unexplained" factors to total cost increases for all schemes (as per the PHMI's results), but under the hypothetical situation in which medical cost-specific inflation that is 1 percentage point higher than CPI is used rather than CPI. As is evident from the table, the "unexplained" portion is negative, or very close to zero, in each year when this alternative hypothetical inflationary measure is used.

Table 2: "Unexplained" factors contributing to total cost increases (all schemes, broad disease burden), taking into account CPI vs. hypothetical medical cost-specific inflation

	2011	2012	2013	2014	Average
Using CPI contribution to total cost increase	-0.38%	0.83%	0.88%	1.33%	0.67%
Using hypothetical medical cost inflation contribution to total cost increase	-1.38%	-0.17%	-0.12%	0.33%	-0.33%

Source: CCHMI Expenditure Analysis Report 2: Overall Cost Trends and Attribution Analyses, July 2018, Table 2.
Notes: Assumes hypothetical medical cost-specific inflation has a 1 percentage point higher impact on cost increases than CPI in each year.

Second, the PF seeks to control for inflation by merely subtracting CPI from observed cost increases. However, as shown in the second RBB Report, this approach is incorrect since it uses an approximate relation between the growth rates of real (i.e. inflation-adjusted) and nominal (i.e. unadjusted) prices, rather than the exact relation. This means that it controls for the effect of inflation inaccurately.

The approximate relation between the nominal and real price growth rates is given as:

$$r_t = g_t - i_t$$

where r_t represents the real price growth rate, g_t represents the nominal price growth rate, and i_t represents inflation.[64] However, the exact relation is:[65]

$$r_t = \frac{g_t - i_t}{1 + i_t}$$

Notably, the approximation only tends toward the exact relation when inflation is low (such that the denominator of the exact relation above is approximately 1). However, in the period under review by the PF, inflation ranged from 5% to 6.7% annually. This means that the use of the approximate relation can be expected to yield materially different results than if the exact relation had been used.

Indeed, as demonstrated in the second RBB Report, the contribution of "unexplained" factors to total cost increases differs substantially between the two relations.[66] For example, on average, the use of the approximate relation overstates the unexplained total cost increase (all schemes, broad disease burden) by 41%, which implies substantially different cost increases in monetary terms.

64 Varian, H.R., 1999. Intermediate Microeconomics: A Modern Approach. WW Norton & Company, p. 189.
65 Varian, H.R., 1999. Intermediate Microeconomics: A Modern Approach. WW Norton & Company, p. 189.
66 RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 21.

In short, while the use of the approximation to adjust for inflation contributes to the inaccuracy of the PF's estimated "unexplained" cost increases, it is the use of CPI in attempting to control for medical cost-specific inflation that really renders the analysis particularly unreliable. Indeed, as we have demonstrated above, even if the issues set out in the sub-sections above are ignored, the PF's use of CPI in its analysis is sufficient to render its findings unreliable.

2.3.5 Relationships assumed to be constant over time

The PHMI's predictions for the full period under review are based on parameter estimates obtained from an economic model constructed using 2014 data alone. The PHMI's justification for this is that it "*minimise[s] the potential distorting effects of inflation, and 2014 data was used as it appears the most complete in terms of schemes and is likely to be the most reliable.*"[67]

However, as indicated in both the first and second RBB Reports, this motivation is fundamentally inconsistent with the use of pre-2014 data for the purposes of predicting costs in these years.[68] If pre-2014 data are not considered reliable enough to be included in the data sample used to produce parameter estimates (i.e. to produce within-sample results), then they should also logically be viewed as not being reliable enough to make out-of-sample predictions using these estimates.

Moreover, the approach relies upon the implicit assumption that the relationships between the control variables and costs do not vary over time, such that parameter estimates obtained using 2014 data also accurately capture the relationships between these variables and costs in previous years.[69] While the PHMI seeks to test this assumption by running the models using 2011 data as compared to 2014 data as the base year and find **[CONFIDENTIAL]**, this analysis is simply not probative since the 2011 data are considered by the PHMI itself to be unreliable, meaning that parameter estimates based on such data will also be unreliable.[70]

As discussed in the second RBB Report, there is no basis to assume that relationships in the data are the same in 2014 as in previous years. On the contrary, it appears likely that the relationships between medical costs and each of the PHMI's control variables would evolve over time.

For example, as the PF explains, there have been a number of changes within the health insurance market in recent years. For instance, the PHMI highlights the *"continuing amalgamation of smaller restricted schemes into open schemes"* and the growth of GEMS (a restricted scheme), as being significant dynamics.[71] The PF also acknowledges an array of new funding strategies that have been adopted over time, including funders consistently reducing the range of benefits covered as a means of making products appear more

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67 CCHMI Expenditure Analysis Report 2: Overall Cost Trends and Attribution Analyses, July 2018, page 6.

68 See RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 9, and RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 22.

69 "*In stating a multiple regression model for time series data, we are assuming a certain form of stationarity in that the B_j do not change over time*" - Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.349.

70 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 31.

71 CCHMI Expenditure Analysis Report 1: Data Quality and Descriptive Statistics, July 2018, page 18.

affordable, and the introduction of more affordable hospital plans that have shifted care toward hospitals and raised costs.[72]

Indeed, the RBB report responding to the PHMI's provisional findings on bargaining power shows that **[CONFIDENTIAL]**.[73] These changes can naturally be expected to affect the relationship between consumers' scheme and plan type choices over time, which would, in turn, affect the coefficient estimates of the member profile, scheme type and plan mix control variables in the PHMI's models.

Accordingly, since the models presented in the PF only use 2014 data to estimate parameters, and do not control for changes in the relationship between explanatory variables and costs over time, the extent to which cost increases are explained for earlier years is likely to be inaccurate. Again, even if one were to disregard the material issues raised in sub-sections above, this issue alone is therefore sufficient render the PF's expenditure analysis results unreliable and the conclusions drawn from it invalid.

2.3.6 Stepwise estimation

In addition to running attribution analyses that include the full set of control variables selected by the PHMI (the results of which were used to calculate the "Explanatory Factors" row in the tables and, in combination with CPI, the "Unexplained Factors" row), the PHMI runs a series of additional regressions that include only a subset of these control variables. Specifically, in an attempt to assess the impact of each control variable individually, the PHMI follows a "step-wise" approach whereby a series of models are run with one control variable removed at each stage. A proxy of the individual impact of each control variable is then calculated as the change in the outcome with the control variable included in the model less the change in the outcome using the remaining control variables while removing the control variable in question.[74]

However, this approach is unreliable. In particular, if one were to assume that the inclusion of the PHMI's full set of chosen controls adequately explains claims costs, yielding parameter estimates that are unbiased, calculations that involve running the model with only a subset of these will necessarily result in parameter estimates that suffer from omitted variable bias, meaning that no reliable inferences can be drawn from them.[75]

2.4 Model validity issues

2.4.1 The importance of model validity and diagnostic testing

In order to ensure that an econometric model provides accurate, non-biased estimates and predictions, it is critical to subject the model to appropriate diagnostic tests. Failure to pass such tests will indicate that there are problems with the model that render its results unreliable, and thus unsound as a basis for drawing conclusions.

72 The PF, paragraph 26, page 8.
73 RBB Economics, Response to the PHM's Provisional Findings: Bargaining Power, 15 October 2018, Figure 4.
74 CCHMI Expenditure Analysis Report 2: Overall Cost Trends and Attribution Analyses, July 2018, page 6.
75 We understand from the Second Expenditure Analysis Response that **[CONFIDENTIAL]**. - PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 23.

Diagnostic tests seek to assess the validity of the model in various ways, including through exploring the model's underlying assumptions, specified structure, explanatory power and fit to the data ("goodness of fit"). Such diagnostics include:

- plots of residuals against fitted values can be used to visually assess whether the model is fully explained by the specified control variables;[76]
- calculating the R^2 statistic provides a measure for the amount of variation in the outcome variable which is explained by the control variables;[77]
- the RESET test can be used to detect for misspecification of the nature of the relationship between control variables and the outcome variable of interest;[78]
- outlier detection is used to determine whether regression results are substantially influenced by observations in the sample with exceptionally large values; and
- checks relating to the model's robustness to other data problems (e.g. missing data, non-random samples, measurement error) should be used to ensure the model's results are not sensitive to small changes in the data or specification.[79]

In order to conclude that a given model is correctly specified, it should satisfactorily pass such diagnostic tests. To achieve this, it is critical to include all relevant explanatory variables in the model, as well as to ensure that the nature of the relationship between these variables and the outcome variable of interest is correctly modelled/specified. A failure to do so will mean that the model will generate parameter estimates that do not accurately reflect the true relationships between the various explanatory variables and costs. This means, in turn, that the model will not provide accurate predictions.

2.4.2 The PHMI's diagnostic tests do not provide a sound basis to conclude that its models are valid

As both the PHMI and stakeholders have recognised, it is important to assess the model's performance by means of relevant diagnostic tests.[80] [81] However, the PHMI continues to present inappropriate diagnostics. Specifically, the diagnostics presented by the PHMI comprise the following.[82]

- A test of the significance of parameters. This test is used by the PHMI in order to measure the explanatory power of its control variables.
- Plots of fitted values versus residuals. These are used as a test for omitted variable bias or incorrect functional form in the model.

[76] See http://blog.minitab.com/blog/adventures-in-statistics-2/why-you-need-to-check-your-residual-plots-for-regression-analysis
[77] Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.40.
[78] Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.281.
[79] See http://yildiz.edu.tr/~tastan/teaching/Handout%2009%20Specification.pdf
[80] PHMI Response to Data Room Submissions, 8 December 2017, page 18.
[81] See RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 14.
[82] CCHMI Technical Annexure to Expenditure Analysis Reports, July 2018, page 17.

- Leverage and Cook's Distance plots. These provide a means for detecting outliers and influential observations.

- Deviance and scaled deviance statistics. These act as a test for the appropriacy of the model structure (choice of distribution and link function).

- Three additional model specifications for the total cost per beneficiary and cost per admission models. These are presented as a test for robustness of the PHMI's chosen model specification and results, namely: (i) a GLM using a log link function and a normal response distribution; (ii) a simple multiple linear regression model; and (iii) a log-transformed multiple linear regression model.

The results of these tests are presented in the Technical Annex to PF as proof that the PF's models are valid, and can therefore be relied upon. However, the reliance upon these tests is misguided, since the specific diagnostic tests performed do not, in fact, assist in determining the validity of the various models to any meaningful extent. For instance:

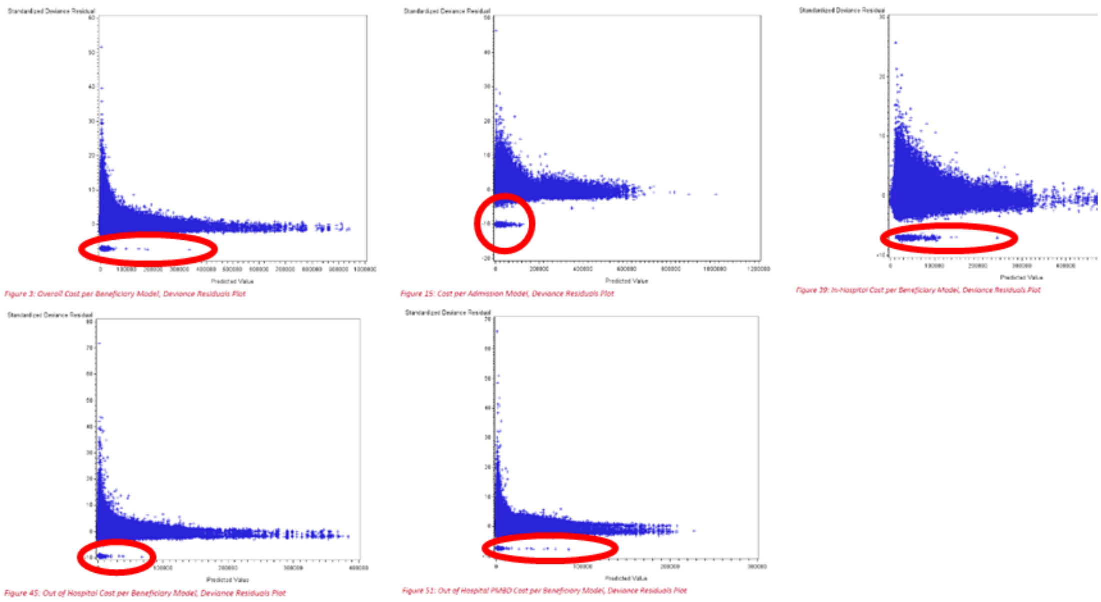
- Since there are a number of relevant factors that are not controlled for in the analysis (discussed in sub-section 2.4.3.2 below), bias is likely to be an important issue affecting the PHMI's results. While residual plots presented in the Technical Annex to the PF are a means of assessing whether a model is well explained by the specified controls, this approach relies on visual inspection alone. It is therefore essential that more robust statistical tests, such as the RESET test, also be implemented.

- The PF's residual plots cannot, in any event, be properly interpreted given the sheer volume of data points they comprise. This means that it is not possible through visual inspection to determine the density or the extent to which residuals are in fact positive or negative.[83] We note that the Second Expenditure Analysis Response suggests that **[CONFIDENTIAL]**, though this does not reflect our concern.[84] In fact, our objection is that any residual plot in the current context cannot provide comfort that a given model is robust given the vast number of data points illustrated.

  Notwithstanding this, there are already identifiable aspects of the residual plots presented in the Technical Annex to PF that may indicate bias. For instance, there appear to be a number of residual plots exhibiting satellite cloud groupings of residuals. For example, Figure 3, Figure 15, Figure 39, Figure 45 and Figure 51 exhibit a cloud of negative residuals close to their South-West corners.[85] This is illustrated by the red circles in Figure 1 below.

83 This is evident in particular in Figure 2, Figure 14 and Figure 26 in the Technical Annex to PF.
84 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 31.
85 While the PHMI explains that these are a group of points with claims marginally above zero that result from incomplete reversals of claims by administration systems, such claims should arguably be dropped or accounted for through the inclusion of a dummy variable. See CCHMI Technical Annexure to Expenditure Analysis Reports, July 2018, page 23.

Figure 1: Graphical illustration of problematic regions in the PF's residual plots



Source: *CCHMI Technical Annexure to Expenditure Analysis Reports, July 2018, Figure 3 (top left), Figure 15 (top middle), Figure 39 (top right), Figure 45 (bottom left) and Figure 51 (bottom right)*

- The PF's tests for the models' fit to the data are not especially relevant. Given the enormity of the sample size used in the analysis, outlier detection (as tested for using Cook's Distance and leverage plots) is simply not an important diagnostic issue. This is because in very large samples any single "influential observation" is not likely to have a material influence on the model.

- The PF's tests of model specification are not especially useful. Since the 1980s it has been known that even if the assumed distribution for a GLM is incorrect, the parameter estimates of GLMs tend to the true population parameters as the sample size tends to infinity, as long as the functional form is correctly specified.[86] [87] Hence, given the enormity of the PHMI's sample size, the parameter estimates of its GLMs should tend to the true population parameters regardless of the chosen distribution and link function, *provided the functional form is correctly specified*.[88] [89]

  This means that the alternative model specifications that the PHMI has applied, namely a variation of the GLM's response distribution and two linear regression models, are not necessary or appropriate in order to determine whether the functional form of the model is correct. Indeed, since these additional models use the same functional form as the PHMI's original models, they cannot provide insight into whether the chosen specification correctly identifies the relationship between the dependent and control variables. Instead, it is most critical that the PHMI tests the validity of the nature of the relationships specified

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86 Nelder, J. and Wedderburn, R. (1972). Generalized Linear Models. *Journal of the Royal Statistical Society,* A,135, 370-384.

87 Gourieroux, C., Montfort, A. and Trognon, A. (1984). Pseudo Maximum Likelihood Methods: Theory. *Econometrica*, 52, 681-700.

88 Nelder, J. and Wedderburn, R. (1972). Generalized Linear Models. *Journal of the Royal Statistical Society,* A,135, 370-384.

89 Gourieroux, C., Montfort, A. and Trognon, A. (1984). Pseudo Maximum Likelihood Methods: Theory. *Econometrica*, 52, 681-700.

between the dependent variable and control variables in its GLMs, rather than testing the particular choice of model.

Furthermore, the PHMI justifies the use of these alternate model specifications on the basis that **[CONFIDENTIAL]**.[90] On the contrary, altering a biased model from a GLM to a linear regression still produces a biased model, even if the two models' results appear broadly the same.

2.4.3 Evidence of model invalidity

As mentioned above, the most important tests of any regression model are tests of whether the model is likely to be biased, for example due to an inappropriate functional form, control variables being incorrectly specified and/or important control variables being excluded. In the event that these tests are failed, a regression model will yield results that cannot be used to reliably infer anything about the population that is being modelled. In contrast, other tests, such as tests for outlying data, if failed, are more easily overcome.

As discussed above, the PHMI either does not conduct such tests, or the ones that it does conduct are of limited probative value. In light of this, we have undertaken our own diagnostic tests in the data room which in our view are more important, appropriate and insightful. These tests are discussed in turn below.

2.4.3.1 Functional form misspecification and model fit

The models presented in the PF are very likely to suffer from functional form misspecification, as already discussed in the second RBB Report. We conducted two common diagnostic tests helpful in assessing the adequacy of the PF's models' functional form and fit. As discussed in sub-section 2.4.1 above, helpful diagnostic tests for these purposes include the RESET test and calculation of the R^2 statistic. More details of the relevance and usefulness of these tests in the current context is discussed in the second RBB Report. [91] The results of these tests were as follows.

- The models fail the RESET test, which indicates that that they have been misspecified in some way and are, in turn, likely to be biased;[92] [93] While the PHMI **[CONFIDENTIAL]** this line of reasoning is incorrect. [94] In fact, large sample sizes only reinforce the significance of this result. For instance, as one academic study found:

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90 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 29.

91 See RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 15.

92 The RESET test is used to test the specification of a linear model. This is done through adding non-linear combinations of the fitted values as control variables and testing these controls for significance. If these controls are found to be statistically significant, this indicates misspecification and the RESET test has been failed. See Sapra, S. (2005). A regression error specification test (RESET) for generalised linear models. *Economics Bulletin*. Vol. 3, No.1 p.1-6.

93 This was done in the January 2018 data room for both the total cost per beneficiary model in 2014 (all schemes, broad disease burden) and the cost per admission model in 2014 (all schemes, broad disease burden), both non-linear terms added to the models were found to be statistically significant at the 0.0001 (or 99.99%) level. Hence, we can be 99.99% certain that the PHMI's models fail the RESET test.

94 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 30.

> *"[T]he RESET tests for GLMs have reasonable power properties in medium to large samples… Applications of such tests to count, qualitative response and duration data models in the GLM family should become routine given their computational convenience and good power properties."*[95]

Moreover, attributing the result to **[CONFIDENTIAL]** cannot explain the failure of the RESET test either, given that **[CONFIDENTIAL]**.[96]

- The models yield low R^2 statistics, suggesting that they do not explain much of the variability in cost outcomes.[97] [98] It is surprising that the PHMI claims **[CONFIDENTIAL]** the second RBB Report explained *"R^2 for GLMs is computed as the square of the correlation between the observed and predicted outcomes*".[99] [100]

  Moreover, while the PHMI suggests that **[CONFIDENTIAL]**, the regulatory context in which the PHMI's models are being applied mean that a low R^2, which is indicative of a poorly performing model remains a material cause for concern.[101]

These results alone cast substantial doubt on whether the PHMI's models accurately capture the relationships between costs and those factors that affect them. This means that the predictions made by these models are unlikely to be reliable and, in turn, any recommendations based on them misinformed.

2.4.3.2 Omitted variable bias

Omitted variable bias arises from the omission of relevant control variables, i.e. variables that can assist in explaining the outcome variable of interest. As already discussed in the second RBB Report, the models presented in the PF are very likely to suffer from omitted variable bias, a view which **[CONFIDENTIAL]** in the Second Expenditure Analysis Response (see sub-section 2.3.1 above).[102]

Notably, the PHMI therefore does not **[CONFIDENTIAL]**. Rather, it simply attempts to downplay the relevance of omitted variable bias by stating that **[CONFIDENTIAL]**.[103]

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95 See page 5 of https://pdfs.semanticscholar.org/dd67/306fd77b2bb6b7012812799301d5be44bd86.pdf

96 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 31.

97 The R^2 statistic gives the proportion of the variance in the outcome variable that is predictable from the specified control variables and will lie within a range between 0 and 1. The closer the statistic to 1, the better the model is said to fit the data. See Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p. 40 and p. 551

98 We computed R^2 statistics in the January 2018 data room for both the total cost per beneficiary model in 2014 (all schemes, broad disease burden) and the cost per admission model in 2014 (all schemes, broad disease burden), and found particularly low R^2 statistics for both models – 0.12 for the former and 0.23 for the latter. This means that only between 12% and 23% of the total variance in cost is explained by the variables used in the regression model.

99 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 30.

100 RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 15.

101 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 30.

102 RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 33.

103 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 34.

However, this does not provide any basis to dismiss the impact of omitted variable bias. Rather, this represents a **[CONFIDENTIAL]**, but of the fundamentals of econometrics.[104]

The omission of relevant explanatory variables from the PHMI's models critically means that *all* of the models' coefficients will be biased and incorrect. This means, in turn that its predictions will also be biased and incorrect.[105] Hence the omitted variables will impact not only the unexplained portions of the models, but the explained portions as well. This should be self-evident given that the unexplained portion is calculated as the difference between the average observed cost change and the average predicted cost change (less CPI). Where the unexplained portion is said to be inaccurate, the explained portion must be inaccurate too.

It should also be noted that these unexplained portions *do* appear to have become the focus of the investigations, even if this was not the original intention. As discussed in sub-section 2.2, the PF draws a number of strong conclusions relating to hospital market power and supplier-induced demand from these unexplained portions. The fact that the PHMI has itself **[CONFIDENTIAL]**, invalidates any conclusions that the PF seeks to draw from them.

Both the first and second RBB Reports have identified prospective relevant control variables that have been omitted from the models presented in the PF.[106] Such control variables include:

- the duration of a beneficiary's scheme membership;
- in-hospital admission details for out-of-hospital claims (where applicable);
- differences in the quality of care across and within various healthcare service providers;
- dummy variables to distinguish between surgical, medical, and maternity admissions; and
- a dummy variable to distinguish between overnight and day admissions.[107]

The PHMI has not addressed these suggestions in its updated analyses, despite the fact that many of these controls are already available in or are computable from the PHMI's dataset.

As already highlighted in the second RBB Economics Report, we were able to test the effect of including a dummy variable to distinguish between medical, surgical, and maternity admissions on the PF's model. We found that these additional dummy variables were each highly statistically significant at the 99.99% level.[108] This implies that we can have 99.99% certainty that the type of admission is an important determinant of the cost per admission – yet this is not controlled for in the PF's models.

A similar concern arises over the apparent differences between day and overnight admissions, which forms a new addition to the attribution analysis presented in the Facilities Annex to the

104 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 34.

105 Indeed, it is important to appreciate that the existence of correlation between even a single control variable and an omitted explanatory variable generally results in *all* parameter estimates being biased. See Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.91.

106 See RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 16, and RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 33.

107 Note that this is an additional relevant control variable that we have identified subsequent to the preparation of the two previous RBB Economics reports.

108 RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 34.

PF.[109] Unfortunately, we were unable to assess the impact of including a dummy variable for day admissions on the models' results during in the August and September 2018 data rooms, as neither the underlying data nor access to the SAS software required to re-run these models were made available to us.

However, the Facilities Annex to the PF in any case presents separate trends for the cost increases of overnight and day admissions. These results indicate notable differences between these two types of admissions.[110] Comparing the cost per life of day admissions model to the night admissions model further in the data room, we found clear differences between the statistical significance of the models' explanatory variables. For example, based on the broad disease burden, admissions with "acute conditions" are highly statistically significant determinants of overnight admittee costs (at the 99% level), but insignificant determinants of day admittee costs.[111] Similarly, based on the narrow disease burden, admissions for "infections" are highly statistically significant determinants of day admittee costs (at the 99% level), but insignificant determinants of overnight admittee costs.[112] This indicates that type of admission would appear to be an obvious and important factor to control for in the PF's models.

In short therefore, our analysis in the data room shows that omitting dummy variables to distinguish between surgical, medical and maternity admissions has a significant impact on the results of the PF's models. Further, while we were not able to test the impact of the omission of the other likely candidate control variables outlined above, we expect that they would have a similarly significant impact. This strongly suggests that the results presented in the PF are likely to suffer from omitted variable bias, rendering all of the estimated parameters unreliable.

2.4.3.3 Sample selection bias

Sample selection bias occurs when a subset of data are systematically absent from the sample as a result of particular attribute of that data. As a result, the sample becomes non-random and may produce results that are not representative of the full population.

In this regard, the PHMI has explored the impact of partial data submissions on its results. Specifically, it compared the results of its attribution analysis using the full dataset of claims (with partial submissions from a number of schemes in each year), against the results obtained using a restricted set of claims data for the three largest administrators (with complete submissions for every year).[113]

The PHMI found that the full dataset exhibited a step-increase in the average age in 2012, relative to the restricted dataset. This translates into a higher explained portion, and hence a

109 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.
110 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 16.
111 This corresponds to coefficients underlying Table 22 and Table 24 of the CCHMI Expenditure Analysis Report 4: Facilities Analyses.
112 This corresponds to coefficients underlying Table 21 and Table 23 of the CCHMI Expenditure Analysis Report 4: Facilities Analyses.
113 PHMI Response to Data Room Submissions, 8 December 2017, page 23.

smaller unexplained portion, of the average annual cost increase when the full dataset is used. From this the PHMI concludes that:

> *"The net effect of including the partial submissions appears to be to explain a higher proportion of the annual cost increase through the explanatory factors… Although some of the figures may change if the partial submissions are excluded, it is unlikely to have a material impact on the conclusions..."*[114]

In light of the fact that the full dataset comprises a larger number of observations and exhibits higher variation in age, it is entirely unsurprising to find a higher explained portion relative to the results for schemes in the restricted dataset only (and less variation in age).[115] However, this result is simply not probative, because the magnitude of the unexplained portion of cost increases is not comparable across the two models.

Indeed, in order for the unexplained portions to be comparable, it must be the case that the beneficiaries in the two datasets exhibit substantively the same claiming behaviour.[116] Failing this the two models will effectively not be comparing substantively the same population over time.

In this regard, the PHMI fails to appreciate that individuals in the schemes with partial data submissions exhibit systematically different claiming behaviour relative to those schemes in the restricted dataset with complete data for the period under review. For example, **[CONFIDENTIAL]**.[117]

This difference is evidently material, and suggests that the beneficiaries associated with schemes added to the data in 2012 are materially different from beneficiaries in the restricted sample, on average. This may be due to unobservable characteristics of these individuals, or the schemes to which they belong, that manifests in the need for less medical treatment, or in the proclivity to claim for smaller amounts from their scheme providers. However, irrespective of the reasons, this creates two issues with the PHMI's results:

- First, the absences of these beneficiaries from the dataset prior to 2012 implies that there is sample selection bias in the dataset in early years. In short, the claims and demographic information for the set of beneficiaries used by the PHMI prior to 2012 (a subset of all beneficiaries) is not representative of the full population of claimants.
- Second, while the parameter estimates obtained from the PF's models are based on the complete sample in 2014, they are consequently applied to make predictions for the restricted sample pre-2012. Since there are material differences in the claiming behaviour of beneficiaries between these two periods, the predictions for the restricted sample before 2012 are likely to be invalid.

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114 PHMI Response to Data Room Submissions, 8 December 2017, page 26.
115 PHMI Response to Data Room Submissions, 8 December 2017, pages 23 to 26.
116 Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.448.
117 Cadiant Partners, Report on the HMI Data Room findings, June 2017, page 2.

The PHMI acknowledges the impact of missing data in the Second Expenditure Analysis Response, by stating that **[CONFIDENTIAL]**.[118] While the PHMI has noted these issues in its report, we do not consider that their implications have been properly taken into account. That the missing data creates sampling selection bias entirely undermines the validity of the PF's models' predictions and results.

2.4.3.4 Measurement error bias

When fitting a model to data, the assumption is made that control variables are known and have been measured accurately. However, where there is measurement error amongst any of the control variables, this assumption is not true and the model will suffer from bias, thereby rendering its estimates and predictions inaccurate.

In the case at hand, the PHMI's narrow disease burden variable appears to be subject to measurement error. This measure defines 18 categories of diagnoses, ranked according to severity. Where beneficiaries fall into more than one of these categories, they are allocated to their most severe category.[119] However, as already raised in the first and second RBB Reports, the PHMI's ranking of clinical flags is not consistent with the size of the parameter estimates generated by its claims costs models.[120]

The PHMI explained in its first response to data room submissions that the ranking was set "*using clinical as opposed to financial severity*".[121] Then, the PHMI **[CONFIDENTIAL]** this response in the Second Expenditure Analysis Response, explaining that **[CONFIDENTIAL]**.[122]

We understand from LHC that there are many examples of medical treatments for which the relationship between clinical and financial severity is not one-to-one. For example, serious ailments which may be treated at low cost include seizures, strokes (excluding patients who require theatre time) and observation for concussion (excluding patients with later complications). Conversely, minor procedures that may incur a high cost include a wrist/finger fracture requiring prosthetic items and theatre time, dental implants, and any other minor procedure where the patient suffers from haemorrhagic disorder.

Thus, a ranking which prioritises clinical severity is particularly problematic for the narrow disease measure, which only allows for a single disease assignment per beneficiary. This is because a beneficiary with two or more conditions may be classified as having a single clinically severe condition, despite a further, albeit less clinically severe, condition potentially explaining a substantial portion of their claims costs. Hence, the PF's narrow measure of disease burden is highly likely to suffer from measurement error.

Notwithstanding this, and despite our previous submissions, and the PHMI's acknowledgement that **[CONFIDENTIAL]**, the PF continues to base its assessment on the

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118 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 8.

119 CCHMI Expenditure Analysis Report 2: Data and Descriptive Statistics, July 2018, page 12.

120 See RBB Economics Discussion of the PHMI's Preliminary Analysis of Medical Scheme Data, 26 July 2017, page 22, and RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 30.

121 PHMI Response to Data Room Submissions, 8 December 2017, page 28.

122 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 23.

narrow measure of disease burden.[123] [124] Nevertheless, in the Second Expenditure Analysis Response, the PHMI suggests that **[CONFIDENTIAL]**.[125]

We would strongly disagree with this recommendation. Firstly, it cannot be appropriate that different measures of disease burden in the population are adopted at different stages of the assessment. Second, for the reasons outlined above, the narrow measure of disease burden is likely to give rise to bias as a result of measurement error.

2.4.3.5 Robustness failure

In the second RBB Economics Report, we highlighted the importance of performing robustness checks on the PHMI's preferred models.[126] Such checks involve identifying how coefficient estimates behave when the model specification is modified, for example by adding, removing, or altering control variables.

If coefficients are robust to such changes (i.e. do not alter by a material amount), this means that the model is likely to provide more reliable estimates. In contrast, if coefficients are highly sensitive to such changes this means that the parameter estimates, and in turn the predictions, produced by the model are unlikely to be reliably representative of those of the true population.

An example of such a robustness check is the use of narrow and broad definitions of disease burden. Notwithstanding the issues regarding measurement error outlined above, the PHMI appears insistent that both the narrow and broad measures adequately control for disease burden in the population. If we were to assume that this is in fact correct, then the results of the models presented in the PF should therefore be robust to the use of either measure, i.e. they should not be sensitive to small changes in this definition.

In this regard, Table 3 below sets out the average contribution of "unexplained factors" to the increases in the various outcome variables modelled by the PHMI, using both the narrow and broad disease burden measures. The table shows that the PHMI's results differ dramatically depending on whether the broad or narrow definition of disease burden is used. In particular, the use of the broad measure often considerably reduces the size of the unexplained increase in the relevant outcomes, rendering this close to zero and in some cases even negative.

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123 The PF, paragraph 313, page 224.
124 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 22.
125 PHMI Summary of Responses to Issues Raised in Submissions on Expenditure Analysis Reports, September 2018, page 22.
126 See RBB Economics Discussion of PHMI's Revised Analyses of Medical Scheme Data, 5 March 2018, page 17, and Lu, X. and White, H. 2014. *Robustness checks and robustness tests in applied economics*. Journal of Econometrics, Elsevier, vol. 178(P1), pages 194-206.

Table 3: Contribution of "unexplained factors" to increases in outcome variables, averaged over 2011 to 2014, obtained from models using the narrow disease profile vs. the broad disease profile

Outcome variable of interest	Narrow disease profile	Broad disease profile
All claims cost trends, all schemes	2.16%	0.67%
Out-of-hospital cost trends, all schemes	0.70%	-0.54%
In-hospital cost trends, all schemes	3.23%	2.28%
Hospital admission rate trends, all schemes	1.19%	0.14%
All admissions cost per admission trends, all schemes	1.99%	1.98%

Source: CCHMI Expenditure Analysis Report 2: Overall Cost Trends and Attribution Analyses, July 2018, Tables 1, 2, 7, 8, 13, 14, 19, 20, 25, 26.

This illustrates that either there is measurement error in the disease burden control (as proposed in sub-section 2.4.3.4 above), or alternatively, that the PHMI's results are indeed sensitive to small changes in the model's specification. In either case, this suggests that the models presented in the PF are not robust, and are therefore unlikely to yield reliable estimates and predictions.

2.4.3.6 Unadjusted standard errors

The use of robust standard errors allows for the fitting of a model whose residuals do not have the same variance (e.g. the variance of one or more of the unobserved factors affecting costs increases with age).[127] Since robust standard errors are valid more often than the usual standard errors, in large sample sizes reporting of these robust standard errors is the norm.[128]

Notably, the PHMI did not compute robust standard errors for its models. This means that the standard errors and significance levels generated from the model are incorrect. This is evident from the fact that, when robust standard errors were computed in the data room, they are materially different from those presented by the PHMI. This leads the PHMI to find a number of control variables statistically significant, when this is not the case when robust standard errors are used.[129]

While this does not affect the model estimates, the reduced number of statistically significant control variables casts further doubt on validity of the PF's models. In particular, since the majority of the member movement and scheme option type control variables become insignificant, and one would intuitively expect these to be important determinants of a beneficiary's claims costs, this gives cause for concern.

127 See Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p. 251.

128 See Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p. 252.

129 Specifically, when computing robust standard errors in the January 2018 data room for the total cost per beneficiary model in 2014 (all schemes, broad disease burden), we found that standard errors in the PHMI's Technical Annex to PF are understated for all control variables. This has a significant impact on the PHMI's results since, when using robust standard errors, seven of the control variables in this model that were originally found to be statistically significant determinants of cost are in fact shown to be statistically insignificant at the 0.05 (or 95%) level. These variables are the Age20GenderM interaction term, the Joiner and Temp beneficiary status dummies, Restricted scheme type, Savings out-of-hospital option type, and the EDO and Network in-hospital option types.

3 Analysis of Expenditure Patterns

3.1 Overview

As detailed in sub-section 1.3, the PF analyses expenditure patterns in two different ways. In particular, the PF compares the cost per admission for each hospital group over time and then the development of in-hospital costs, specifically, across all hospital groups.

As we discuss in further detail below, with regards to the comparison of cost per admission across hospital groups, the PF finds that the three large hospital groups have higher costs per admission than other facilities. The PF considers that this may reflect relative inefficiency on the part of these groups. However, we show below that the PHMI's own analyses of cost per admission by hospital group, when adjusted for case mix, not only do not support this finding, but in fact directly contradict it.

With regards to the development of in-hospital costs over time, the PF finds "*increasing and higher ward and theatre fees"* to be reflective of the hospital groups' market power. However, as we explain in more detail below, we find that the available evidence does not support this conclusion.

3.2 Cost per admission by hospital group

The PF's find that "*the three large groups have higher unadjusted costs per admission than NHN and the other independent hospitals"*. [130] This finding appears to be based on the results presented in Table 27 of the Facilities Annex to the PF, which sets out the unadjusted average total cost per admission for each hospital group (Netcare, Mediclinic, LHC, NHN hospitals, other independent hospitals, state hospitals) for each year from 2010 to 2014.[131]

Further, while the PF considers that differences between the three major hospital groups as compared to the NHN and other independent hospitals may be driven, in part, by differences in case mix, it asserts that case mix "*may not explain the difference entirely*". This is followed directly by the conclusion that *"the higher unexplained costs per admission reflect some inefficiencies inherent in the system"*. [132]

However, in our view, the PF's conclusion that the three major hospital groups are less efficient than the NHN and other independent hospitals is incorrect. Indeed, the PF does not contain any evidence to support its finding that differences in costs per admission are not simply the result of case mix, while several pieces of analysis conducted by the PHMI entirely contradict the PF's conclusion.

First, the PHMI did, in fact, conduct a comparison of costs per admission across hospital groups that sought to adjust for case mix. In particular, in the Facilities Annex to the PF the PHMI undertook what it described as *"a direct cost comparison between admissions to the*

130 The PF, paragraph 350, page 233.
131 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 21.
132 The PF, paragraph 350, page 233.

various hospital groups on a case-mix adjusted basis".[133] This was performed by re-running its cost per admission attribution analysis (with the usual full set of control variables) now also including a dummy control variable for each hospital group, with the PHMI noting that the *"[a]nalysis of these parameters should allow for a case-mix adjusted comparison of the groups"*.[134]

The results of this analysis are replicated in Table 4 below, as presented in the Facilities Annex to the PF. The percentages presented in the table reflect the additional cost for each hospital group relative to Netcare (used as the base category).

Table 4: Hospital groups total cost per admission comparison (broad disease burden), 2010-2014

Group	2010	2011	2012	2013	2014
Netcare	0.00%	0.00%	0.00%	0.00%	0.00%
Life Healthcare	-3.41%	-3.51%	-3.07%	-2.33%	-1.37%
Mediclinic	-3.61%	-4.77%	-4.44%	-2.49%	-0.22%
NHN	3.44%	6.87%	6.74%	3.67%	4.10%
Other	-5.61%	-2.27%	0.39%	-1.26%	0.30%
State	-32.27%	-25.72%	-27.14%	-34.22%	-34.11%

Source: CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 39, Table 66.
Note: The figures for Netcare are shown as zero since it used as the base category.

As the table shows, the cost per admission for NHN hospitals is between 3.44% and 6.87% more expensive than that of Netcare, once adjusted for case mix (and all other control factors). In other words, when adjusting for case mix, NHN hospitals were found to have a higher cost per admission than Netcare.

In contrast the cost per admission to LHC and Mediclinic hospitals is less expensive than to Netcare in every year of the period analysed. In other words, when adjusting for case mix, LHC and Mediclinic were found to have a lower cost per admission than Netcare, and thus by implication also than NHN hospitals.

The position of "Other" independent hospitals relative to Netcare changes over the period. Specifically, in 2010 and 2011, as well as in 2013, these hospitals are shown to be relatively cheaper than Netcare, though in 2012 and 2014 they are exhibiting a virtually equal cost per admission to Netcare. Finally, state hospitals are found to be the most inexpensive facilities each year.

This analysis indicates that, contrary to the assertion in the PF, once case mix is controlled for, costs per admission are not highest for the three large hospital groups. Instead, adjusted costs per admission for these three groups are found to be lower than that of NHN hospitals

133 CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 38.

134 This is done by taking the exponent of the estimated coefficient and subtracting 1, which yields the percentage change in the dependent variable associated with a unit change in the independent variable. See Wooldridge, J. (2000). *Introductory Econometrics: A Modern Approach* (First Edition). United States of America: Thomson Learning, p.183-4.

in every year. According to the logic of the PF (namely, that differences in costs per admission are attributed to relative levels of efficiency), this would imply that the three hospital groups are *more*, rather than less, efficient than the NHN.

In addition, the Facilities Annex to the PF contains a second, separate piece of analysis, focussing on increases in cost per admission for each hospital group separately. This analysis yields annual explained and unexplained increases in cost per admission between 2010 and 2014 for each hospital group. This allows for a comparison between the hospital groups of the extent to which increases in cost per admission over time are explained by the PHMI's control variables.

The results of this analysis are summarised in Table 5 below. In particular, the table shows, for each group, the average increase in the unadjusted cost per admission over the period, and the extent to which CPI, explanatory factors and unexplained factors contribute to the increase over the period 2010 to 2014.

Table 5: Average cost per admission trends by hospital group, broad disease burden, 2010-2014

	Netcare	Mediclinic	Life	NHN	Other	All
Total increase	7.85%	10.53%	8.20%	8.79%	10.08%	**8.79%**
- CPI	5.60%	5.60%	5.60%	5.60%	5.60%	**5.60%**
- All explanatory factors	0.61%	3.16%	1.02%	0.15%	0.52%	**1.20%**
- Unexplained factors	1.64%	1.77%	1.58%	3.04%	3.96%	**1.98%**

Source: CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, Tables 30, 32, 34, 36, 38, and 40.
Notes: Table 40 (Other Independent Hospitals) appears to be an exact copy of Table 38 (NHN Hospitals), and the text which describes Table 40 does not correspond the table's figures. Hence, we have relied on the previous version of this table found in the December 2017 Facilities Report (Table 36) which corresponds to the figures in the text in the July 2018 Facilities Annex.

As seen in the table, the overall average unexplained increase in cost per admission across all hospitals over the period analysed is 1.98%. Amongst the three large hospital groups, the average unexplained increase ranges between 1.58% (LHC) and 1.77% (Mediclinic), such that all of the three large hospital groups exhibit below average unexplained increases. In contrast, the unexplained increase for NHN hospitals is considerably higher, at just over 3%, while the figure for other independent hospitals is higher still, at close to 4%.

Thus the PHMI's own analysis shows that, once not only case mix but also a broader set of explanatory factors have been controlled for, both the NHN and other independent hospitals exhibit larger unexplained increases in cost per admission than the three major hospital groups. Accordingly, if one were to again follow the PF's logic that, *"higher unexplained costs per admission reflect some inefficiencies inherent in the system"*, these results would suggest that inefficiencies are, in fact, more prevalent within the NHN and other independent hospitals than the three large hospital groups.

In short therefore, the PHMI's own analyses directly contradict the PF's assertion that higher costs per admission of the three large hospital groups are driven by inefficiency rather than by case mix. Moreover, the analysis contained within the PF also indicates that unexplained increases in cost per admission are not, in fact, higher for the major hospital groups as is alleged, but rather higher unexplained increases are observed for the NHN and independent hospitals. If one were to apply the PF's own logic that any unexplained increases in costs per admission are reflective of inefficiencies, then this would suggest that the major hospital groups are more, rather than less, efficient than the NHN and other independent hospitals.

3.3 In-hospital costs per admission

The PF argues that its findings of "*increasing and higher ward and theatre fees*" relative to other in-hospital costs may be a consequence of hospitals no longer being able to earn additional margins through rebates on surgical and consumables fees since 2007/2008.[135] The argument is that hospitals increased margins on ward and theatre fees to compensate for lower margins on surgical and consumables fees. Moreover, the PF suggests that this is evidence of hospitals being able to exercise market power, by virtue of the fact that medical schemes did not pursue this issue, suggesting they have limited power to countervail that of hospitals.[136]

We find the PF's evidence and conclusions drawn therefrom entirely deficient and unfounded, for a number of reasons.

First, the PF appears to base its claim that ward and theatre fees are "*increasing and higher*" relative to other in-hospital costs on two tables presented in the Facilities Annex to the PF that present hospital costs per admission broken down by tariff type each year. These tables are combined and presented in Table 6 below. However, these tables do not provide any evidence to support its claim.

Notably, all of the cost categories against which ward and theatre fees are compared have either increased at a faster rate than theatre and ward fees or, according to the PF itself, serve as unreliable comparators.[137] For instance, the PF explicitly notes that NAPPI figures may be impacted by the use of in-house tariff codes, and that ARMs figures "*seem unstable*".[138] This leaves only the "Other" category of costs, which grew at a faster rate than theatre and ward fees in every year.[139] Indeed, more generally ward fees increased by a substantially smaller percentage than "All" items (as indicated in the last column) between 2011 and 2012, and by only slightly greater percentages from 2012 to 2014, while theatre fees increased by smaller percentages than "All" items in all but one year.

In addition, based on our analysis during the August 2018 data room, **[CONFIDENTIAL]**. This can be seen in the tables presented in Annex B.

135 The PF, paragraph 353, page 233.
136 The PF, paragraph 354, page 234.
137 For some categories both are true.
138 The PF, paragraph 356 and 357, page 234.
139 In addition, the PHMI acknowledges that this category is comprised of numerous individual charges (including some in-house NAPPI code items), meaning that it is not possible to discern what is driving these observed substantial year-on-year increases in "Other" fees. See CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, page 31.

Table 6: Hospital cost per admission trends by tariff type, 2010 - 2014

Year	Ward		Theatre		NAPPI		ARM		Other		All	
	Cost	Annual Increase	Cost	Annual Increase	Cost	Annual Increase	Cost	Annual Increase	Cost	Annual Increase	Cost	Annual Increase
2010	5,962		2,243		2,710		340		2,706		13,961	
2011	6,569	10.19%	2,389	6.53%	2,769	2.20%	345	1.49%	3,009	11.20%	15,082	8.03%
2012	6,939	5.63%	2,545	6.54%	2,873	3.76%	395	14.64%	3,550	17.96%	16,303	8.10%
2013	7,546	8.74%	2,772	8.90%	2,932	2.06%	426	7.78%	3,976	12.00%	17,652	8.27%
2014	8,224	9.00%	2,981	7.53%	2,996	2.16%	541	27.03%	4,394	10.52%	19,136	8.41%
Average		8.37%		7.37%		2.54%		12.34%		12.88%		8.20%

Source: CCHMI Expenditure Analysis Report 4: Facilities Analyses, July 2018, Tables 47 and 48

Second, even if theatre and ward fees were found to be increasing at a greater rate than other costs, this would not in and of itself provide any support for the PF's claim that this is a result of market power. On the contrary, it would be entirely unsurprising to find the fees of different items increasing at different rates, given that each item is likely to be influenced by different kinds of underlying costs.

For example, we understand from LHC that NAPPI codes are set at a rate negotiated between hospitals and their suppliers, while ward and theatre tariffs are set at a rate negotiated between hospitals and funders. Moreover, theatre and ward tariffs will be impacted by changes in equipment costs and new technologies.

Third, the use of claims cost data alone cannot in any case offer insights into margins earned by the hospital groups. Margins are derived from a combination of both price and cost. While hospital claims cost data can be used to show the price of hospital care incurred by admittees, no corresponding data are provided by the PHMI which show the cost of care provision incurred by the hospitals.

Even if the PHMI's claims cost data shows the price of particular aspects of hospital care going up, it is therefore not possible for the PHMI to conclude that margins on these items are increasing absent the collection of cost data which shows the cost of provision of these items are remaining constant or declining. Indeed, while the PF initially postulates a more cautious theory from these data ("*increasing and higher ward and theatre fees could be an aftermath of the anticompetitive transfer of rebates*" [emphasis added]), this is immediately followed by the drawing of a much more definitive conclusion absent any further evidence ("*[t]o correct these rebates… the hospital groups shifted the margins on these products to ward and theatre tariffs*").[140]

Fourth, if one were to assume that hospital groups did hold market power in 2008 that enabled them to shift margins to theatre and ward fees, it is illogical to expect this to be reflected in

[140] The PF, paragraph 353, page 233.

disproportionate increases in theatre and ward fees over time. Rather, such market power would have allowed hospitals to undertake a shift of margins with immediate effect. However, since the data used by the PF only commences in 2010, the PF contains no evidence that this occurred.

Fifth, and relatedly, if hospital groups already had market power as of 2008, they could logically have sought to increase ward and theatre fees prior to the removal of rebates on surgicals and consumables.

Sixth, it is in any case difficult to reconcile the PF's finding that hospitals are exercising market power with the PHMI's profitability analysis which shows that hospitals are not earning excessive returns. As explained in the RBB report responding to the PHMI's provisional findings on profitability, an absence of excessive returns means that competition is functioning effectively.[141]

Accordingly, there are a number of flaws with the PF's argument regarding hospitals' *"higher and increasing"* ward and theatre fees. These fees are compared against unreliable and/or meaningless fee categories, and hence there is no evidence that these fees are actually increasing at a faster rate than other costs (though even if this were so it would not imply market power). Moreover, not only is it illogical that market power would manifest itself in increasing theatre and ward margins, but the evidence presented in the PF does not, in any case, offer any insights into such margins.

141 RBB Economics, Response to the PHM's Provisional Findings: Profitability Analysis, 15 October 2018.

4 Price Determination and Price Increases

As discussed in sub-section 1.4, the PF expresses three concerns with regards to current tariff pricing:[142]

- first, healthcare prices are "*inherently inefficient and derived from an anticompetitive, collusive base price*";
- second, ward and theatre tariffs contain "*historical inefficiencies which have not been corrected for*"; and
- third, the persistence of FFS as a model of pricing "*further entrenches inefficiencies in the system*".

The second of these concerns has already been addressed in sub-section 3.3 above, where we set out that the evidence provided in the PF in support of this claim is neither relevant, nor reliable. Similarly, the third concern is addressed in detail in the RBB report responding to the PHMI's provisional findings on bargaining power, and hence we do not address it in detail here.[143] However, we do note that FFS tariffs are shown in the PF to have increased by only 0.6% more than ARM tariffs, and no analysis is presented as to whether this differential is significant or may be explained by other factors.[144]

As such, in this section we focus only on the first concern. In this regard, although the PF finds that hospital prices have increased only marginally more than CPI over the period analysed, it argues that prices may still exceed competitive levels to the extent that present day tariffs are determined off an anticompetitive base (stemming from before 2004). This concern appears to stem from the fact that negotiations between hospitals and funders take place over tariff increases relative to the previous year, such that historical collusive prices have merely been maintained over time.

In our view, the PF's arguments regarding past and present day anticompetitive price levels are highly flawed, for the following reasons.

First, the PF does not present an assessment of historical prices nor does it provide a benchmark competitive level against which actual prices could be compared. Indeed, in order to conclude that current prices are above competitive levels, the PF would need to construct a counterfactual for what competitive prices should have been.[145]

However, no such benchmark is presented as a point of comparison to show that pre-2004 prices were above competitive levels. Indeed, the PF even notes that *"there is no empirical*

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142 The PF, paragraph 362, page 235.

143 RBB Economics, Response to the PHM's Provisional Findings: Bargaining Power, 15 October 2018.

144 The PF, paragraph 363, page 235.

145 "*This assessment will usually be made by comparing the actual or likely future situation in the relevant market (with the dominant undertaking's conduct in place) with an appropriate counterfactual, such as the simple absence of the conduct in question or with another realistic alternative scenario, having regard to established business practices.*" – European Commission Article 82 Guidelines, para 82.

evidence that the coordinated approach to tariff setting prior to 2004 resulted in higher than competitive tariffs".[146] Thus, its assessment of historical prices is entirely speculative.

Second, if the PHMI had conducted any comparative pricing assessment, there is no reason to expect that this would have revealed prices under the prior collective bargaining approach to tariff negotiations to be substantially above competitive levels. Indeed the PF itself acknowledges, *"the collusive outcome may not have been above, or much higher than, the competitive price"*.[147] The PF goes on to say that *"collective bargaining could yield efficient outcomes in the sense that it unifies healthcare tariffs, with both sides exercising bargaining power, thus simplifying tariff-setting in a complicated industry with many players"*.[148]

Hence, prices under collective bargaining would only have the potential to give rise to supra-competitive prices if medical schemes lacked effective countervailing power. However, this would be extremely surprising given that schemes negotiated collectively at this time, and in fact, as set out in the RBB report responding to the PHMI's provisional findings on bargaining power, schemes continue to possess substantial bargaining power even though they no longer negotiate collectively.[149] Thus, even if the approach to setting tariffs under the prior collective bargaining was found to amount to a breach of competition law, this does not in any way imply that the resulting tariffs were above competitive levels.

Third, the finding that prices were above competitive levels as of 2004 cannot be reconciled with the findings of the PHMI's cost attribution analysis. In particular, if the PHMI had found that pre-2004 collusive prices have been maintained to the present day, this would imply that collusive prices were present in 2010, which forms the start of the period analysed in the PHMI's attribution analysis.

However, if prices were already collusive as of 2010, then unless market power has been increasing over time (a finding that the PHMI does not allege or evidence and would be inconsistent with the PHMI's concentration analysis results), market power would not provide a plausible explanation for any unexplained price increases above CPI thereafter. This is because if a firm possesses market power it will already be able to raise prices, and hence its margins, as high as it profitably can above competitive levels. Hence, in subsequent years it will no longer be rational for the firm to seek to increase prices by a greater extent than costs (since if it could extract even greater margins it would already have done so).

Finally, if prices were found to be higher than competitive levels this would imply that hospitals would be making supra-competitive profits. However, this is not consistent with the PF's findings on profitability, where the PF states that *"profits of all three hospital groups are not excessive per se"*.[150]

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146 The PF, paragraph 367, page 236.
147 The PF, footnote 168, page 235.
148 The PF, paragraph 368, page 236.
149 RBB Economics, Response to the PHM's Provisional Findings: Bargaining Power, 15 October 2018.
150 The PF, paragraph 463, page 252.

Annexes

A Approximation of Margins of Error

The results of the calculations relating to observed costs are displayed in Table 7 below. The first row presents the cost per admission point estimate per year from the model presented in the PF (described in bullet 2 of sub-section 2.3.2.3 above), the second and third row present the upper and lower bound of the 95% confidence interval centred on this point estimate (described in bullet 3 of sub-section 2.3.2.3 above), and the fourth row shows the approximate lower bound annual increase computed according to the description in bullet 4 of sub-section 2.3.2.3 above.

Table 7: Observed cost per admission (all schemes, broad disease burden), 2010 to 2014

Observed cost per admission	2010	2011	2012	2013	2014	Average
Average value (ZAR)	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Lower bound of confidence interval (ZAR)	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Upper bound of confidence interval (ZAR)	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Approximate lower bound annual increase (%) – using row 2 and 3	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**

Source: RBB data room analysis.

The results of the calculations relating to predicted costs are displayed in Table 8 below. The first row presents the average predicted cost per admission per year (described in bullet 1 of sub-section 2.3.2.3 above), the second and third row present the upper and lower bound of the 95% confidence interval centred on this point estimate (described in bullet 3 of sub-section 2.3.2.3 above), and the fourth row shows the approximate upper bound increase computed according to the description in bullet 5 of sub-section 2.3.2.3 above.

Table 8: Predicted cost per admission (all schemes, broad disease burden), 2010 to 2014

Predicted cost per admission	2010	2011	2012	2013	2014	Average
Average value (ZAR)	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Lower bound of confidence interval (ZAR)	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Upper bound of confidence interval (ZAR)	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Approximate upper bound increase (%) – using row 2 and 3	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**

Source: RBB data room analysis.

B Proportion of Total Cost per Admission Accounted for by Ward and Theatre Fees

During the August 2018 data room, we had intended to investigate the analysis of ward and theatre fees presented in the PF. However, we were unable to do so since neither SAS nor the dataset used by the PHMI in the expenditure analysis were provided during the data room. We were, however, able to access the admissions dataset used for the supplier-induced demand analysis (which, as we understand it, uses the same base dataset as that of the expenditure analysis) and analyse this using STATA.

We considered the size of ward and theatre fees in comparison to the total cost per admission. We found **[CONFIDENTIAL]**. The proportion of total cost per admission that is accounted for by each of theatre and ward fees, as computed in the data room, are presented in the tables below. Notably, **[CONFIDENTIAL]**.

Table 9: Proportion of total cost per admission attributable to ward fees by hospital group, 2010-2014

	2010	2011	2012	2013	2014	Average
Netcare	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Mediclinic	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Life	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
NHN	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Other	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**

Source: RBB data room analysis

Table 10: Proportion of total cost per admission attributable to theatre fees by hospital group, 2010-2014

	2010	2011	2012	2013	2014	Average
Netcare	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Mediclinic	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Life	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
NHN	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**
Other	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**	**[CONFIDENTIAL]**

Source: RBB data room analysis