Part One: The Relationship between Spending and Wins

Data Acquisition: To examine the relationship between team spending and wins, data was collected from spotrac.com. Team salary cap data was acquired using the "NHL Team Salary Cap Tracker" and consisted of 10 variables including: team, record, number of active players, average age of team, forward cap, defense cap, goaltender cap, estimated total cap, cap space remaining, and a ranking based on cap space remaining with one being the most cap space remaining. Team cash payroll data was acquired using the "NHL Team Cash Payroll Tracker" and consisted of 6 variables including: team, forward cash, defense cash, goaltender cash, total cash, and a ranking based on total cash with one being the most total cash. Data was copied and pasted into one of two excel spreadsheets, one for salary cap data and one for cash payroll data. This was repeated for the 20-21, 21-22, and 22-23 NHL seasons. Once the data was compiled, the excel sheets were converted into CSV files and were read into R.

Data Filtering and Cleaning: Once the two CSV files were read into R they were joined by the team and year variables. The record variable was obtained in a format that did not allow for analysis of wins alone (i.e., 41-33-7 (89)). As such, string manipulation and regular expressions were utilized to break the record variable into four new variables: wins, losses, overtime losses, and points. The new variables were then converted from characters into numerics. Finally, two additional variables were created by dividing the total cash and total cap variables by one million, respectively.

Statistical Relationship: To determine the statistical relationship between wins and spending, data from the last three NHL seasons was considered. This time frame was selected to focus on the team's performance following Steve Yzerman being named Executive Vice President and General Manager of the organization in 2019 (Crawford 2019). As mentioned previously, both salary cap and cash payroll data were acquired. With a hard salary cap of $82.5 million enforced

across the league, and many teams being at exactly or slightly below that limit, salary cap may not provide valuable insight (Schram 2022). Due to cash payroll detailing how much a team is actually paying its players per year, rather than the average amount a player makes a year in their contract, it could provide a better understanding of the relationship between wins and spending. Similarly, the definition of winning was considered for this analysis. While maximizing the total number of wins in the regular season is a primary goal of a team, it could be argued that making the playoffs is also a primary goal. As such, both regular season wins and total points towards playoffs were used as indicators of winning. To determine the strongest relationship amongst spending and winning, correlation between all four variables described were calculated and can be seen in Table 1.

Variables	Correlation
Salary Cap - Wins	0.38
Cash Payroll - Wins	0.57
Salary Cap - Points	0.36
Cash Payroll - Points	0.55

Table 1. Correlations between spending variables and win variables for all NHL teams in the 20'-21', 21'-22', and 22'-23' seasons.

The correlation between total cash payroll and total wins is the highest at 0.57, indicating a moderately strong, positive linear relationship between the two variables. This relationship can be seen visually in Figure 1 and is highlighted by the blue trend line.

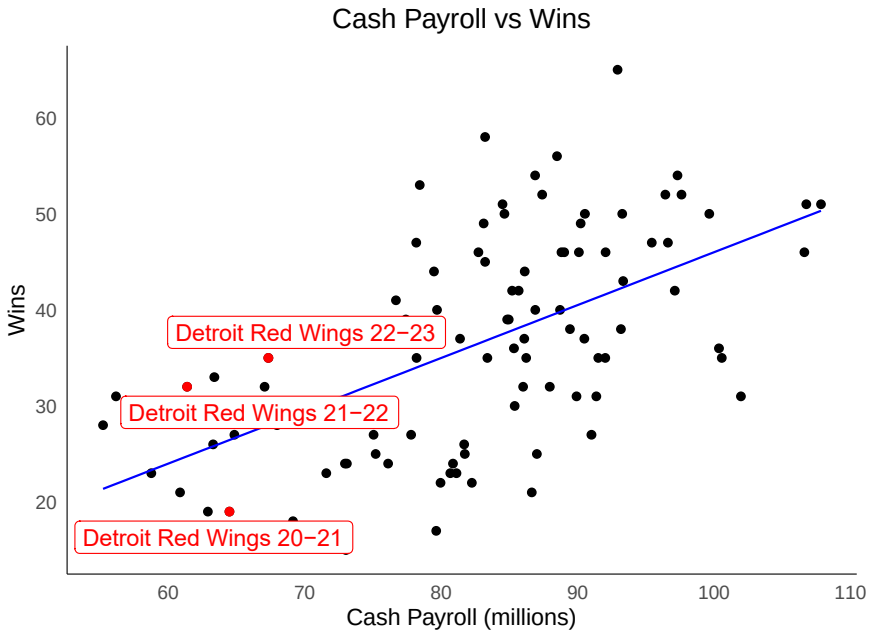

Figure 1. Cash payroll (in millions) vs. Wins for all NHL teams in the 20'-21', 21'-22', and 22'-23' seasons.

Where We Stand: Referring back to Figure 1, the Red Wings' past three seasons have been highlighted in red. Our organization has consistently been one of the lowest spenders in the league and has subsequently seen less wins. To gather a deeper understanding of how our recent spending compares to other teams in the league, the average percent changes in spending year-to-year were calculated and can be seen in Table 2. Note that as data was not collected for the 19'-20' season, the percent change could not be calculated for the 20'-21' season.

Year	Avg. Cash Payroll (M)	Avg. Salary Cap (M)	% Change Cash Payroll	% Change Salary Cap
20-21	80.5	78.7	N/A	N/A
21-22	81.9	78.4	1.76	-0.37
22-23	86.9	80.4	6.08	2.57

Table 2. League-wide average cash payroll (millions), average salary cap (millions), percent change in cash payroll and percent change in salary cap for the 20'-21' through 22'-23' seasons.

The same calculation was performed for the Red Wings alone and the results can be seen in Table 3.

Year	Cash Payroll (M)	Salary Cap (M)	% Change Cash Payroll	% Change Salary Cap
20-21	64.5	73.7	N/A	N/A
21-22	61.4	69.6	-4.81	-5.65
22-23	67.3	74.4	9.7	6.95

Table 3. Detroit's cash payroll (millions), salary cap (millions), percent change in cash payroll and percent change in salary cap for the 20'-21' through 22'-23' seasons.

Compared to the league averages, Detroit significantly reduced both cash payroll and salary cap between the 20'-21' and 21'-22' seasons. In hindsight, it's clear these reductions were done with a plan for a considerable number of signings during free agency at the tail end of the 21'-22' season. It should be applauded that Yzerman was able to add five new players - Andrew Copp, Ben Chiarot, Dominik Kubalik, Olli Maatta, and David Perron – to the roster with only a 9.7% increase in cash payroll for the team as a whole. Ultimately, the Wings' net percent change between the 20'-21' and 22'-23' seasons was 4.89 and 1.3 for the cash payroll and salary cap, respectively. These numbers fall below the league-average net percent changes of 7.84 and 2.2, confirming that other teams in the league are increasing their spending at a faster rate.

When considering the relationship between wins and spending for the Wings in particular, it's important to note that due to the nature of the game and contract structures, more spending does not automatically mean more winning and vice versa. For example, in the 20'-21' seasons we won 19 games and acquired 48 points. In 21'-22', we see a massive jump in wins to 32 and 74 points despite decreasing cash payroll and salary cap. However, if we look deeper at the reasoning behind this success it's clear that it has to do with younger players and their contracts. Moritz Seider and Lucas Raymond were both rookies that had an amazing year in the 21'-22' season but were being attributed cap hits worth less than $1 million. As they are locked into their entry-level contracts for several more years, as mandated by the league, their pay does

not reflect their contribution to winning (Murphy 2022). The same can be said of players who are signed to extensive contracts but are declining in point production towards the end of the contract despite being paid the same amount each year. Regardless of whether it's over- or under-payment, disparities in contracts lead to a weaker relationship between spending and wins. For this reason, factors beyond spending alone should be considered when looking to increase the number of wins.

Part Two: Current and Future Organizational Value

Data Acquisition: Data regarding the current value of our organization, and all others across the league, were obtained from Forbes.com. As the data was not in an easily extractable format and was spread amongst 32 separate web pages, web scraping and crawling was utilized. The variables obtained in the scraping/crawling process include team, ranking (in terms of value), value, owner(s), championships, year purchased, price paid for purchase, revenue, operating income, debt-to-value-ratio, player expenses, gate receipts, wins-to-player cost ratio, revenue per fan, metro area population, and media partners.

Data Filtering and Cleaning: The team variable was scraped in a format that included the ranking within the name (i.e., #11 Detroit Red Wings). String manipulation was used to split this variable into two separate variables – team and rank – which was followed by the removal of the pound sign in rank and conversion into a numeric. Additionally, many of the cost-related variables were in a shortened format with 'M' or 'B' abbreviations and dollar signs. All financial variables were converted to millions, without an 'M' or dollar sign, to keep comparisons amongst teams uniform.

Current Value: According to the data collected, our organization is the 11th most valuable in the NHL at $1.03 billion. This continues the positive trend in team value we've seen over the past ten years (excluding 2020 due to COVID-19-related financial losses). We've managed to more

than double revenue from $74 million to $187 million between 2021 and 2022, respectively. Most impressively, we've recovered from an operating income of -$37 million in 2021 to $61 million in 2022. While there was a slight increase in player expenses from $51 million to $55 million, the current amount is still less than any season between 2014 and 2020. All financial indicators for the Red Wings appear to be trending in the right direction.

To compare our current value to the rest of the league, total team value and operating income were plotted, as can be seen in Figure 2.

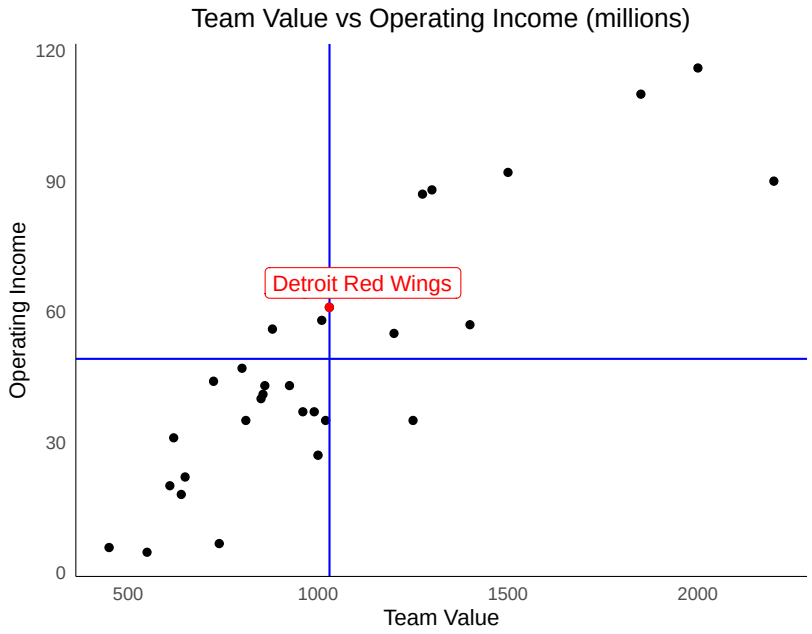

Figure 2. Team Value vs. Operating Income (millions) for all NHL teams in the 2022 calendar year.

The horizontal blue line represents the average operating income of all teams while the vertical line represents the average team value. The Red Wings fall directly on the average team value but are above the average operating income. This indicates that we are maintaining a higher operating income than would be expected given our value, another confirmation we are managing finances well.

Future Value and Sale Price: To calculate future value and an optimal sales price in five years, a discounted cash flow analysis was performed. The goal of such an analysis is to choose the investment option that maximizes net present value, which is essentially an estimate of the worth of an investment after a certain period of time (Miller 2015). The net present value was calculated using the below formula outlined by Miller (2015):

$$Y = \frac{X}{(1+r)^N}$$

Where Y is the net present value, X is the cash flow in minus the cash flow out, r is the discount rate or cost of capital, and N is the number of periods. To perform this calculation, some underlying assumptions were made. First, the value of NHL teams is at an all-time high and is expected to keep growing (Ozanian and Teitelbaum 2022). This in combination with inflation and rising tickets prices will likely drive revenue to continue to grow for the foreseeable future. For this analysis, we will assume revenue (cash in) increases by approximately $15 million a year. Second, the discount rate, or cost of capital, is assumed to be 8%. Finally, the number of periods is assumed to be 5, as the intention is to identify an ideal sales price after 5 years. Three different scenarios will be considered: a $1.5 billion sales price and zero cost control managing the organization, a $1.5 billion sales price with strict cost control, and a $2 billion sales price with strict cost control. The results from the analyses can be observed in Table 4.

Option 1: $1.5 Billion Sales Price - No Cost Control					
Index of Year	Season or Event	Cash In (millions)	Cash Out (millions)	Cash In - Cash Out (millions)	Discounted Cash In - Cash Out (millions)
0	Purchase	0	1030	-1030	-1030.00
1	22-23	200	260	-60	-55.56
2	23-24	215	270	-55	-47.15
3	24-25	230	280	-50	-39.69
4	25-26	245	290	-45	-33.08
5	26-27	260	300	-40	-27.22
5	Sale	1500	0	1500	1020.87
				Net Present Value:	-211.83
Option 2: $1.5 Billion Sales Price - Strict Cost Control					
Index of Year	Season or Event	Cash In (millions)	Cash Out (millions)	Cash In - Cash Out (millions)	Discounted Cash In - Cash Out (millions)
0	Purchase	0	1030	-1030	-1030.00
1	22-23	200	225	-25	-23.15
2	23-24	215	225	-10	-8.57
3	24-25	230	225	5	3.97
4	25-26	245	225	20	14.70
5	26-27	260	225	35	23.82
5	Sale	1500	0	1500	1020.87
				Net Present Value:	1.64
Option 3: $2 Billion Sales Price - Strict Cost Control					
Index of Year	Season or Event	Cash In (millions)	Cash Out (millions)	Cash In - Cash Out (millions)	Discounted Cash In - Cash Out (millions)
0	Purchase	0	1030	-1030	-1030.00
1	22-23	200	225	-25	-23.15
2	23-24	215	225	-10	-8.57
3	24-25	230	225	5	3.97
4	25-26	245	225	20	14.70
5	26-27	260	225	35	23.82
5	Sale	2000	0	2000	1361.17
				Net Present Value:	341.94

Table 4. Discounted cash flow analysis for 5-year investment with three options: $1.5 B sales price with no cost control, $1.5 B sales price with strict cost control, and $2 B sales price with strict cost control.

Note that although the analysis begins with a “purchase”, this is not meant to represent the sales price, just the current value of the team. From there, we can simulate different management options to determine how best to maintain or increase the value of the team for an optimal sales

price in five years. First and foremost, we can see that strict cost control is vital to preventing monetary loss. It was found that maintaining cash out, or costs, at approximately $225 million would allow us to break-even with a $1.5 billion sale price in five years. This will be a challenge to sustain and will require a constant effort to increase efficiency in all aspects of the organizations to keep costs steady year-to-year despite the natural devaluation of capital due to inflation. If we're looking to make a significant profit from the sale of the team, then a $2 billion sale price would be ideal. Just as with option two, we'd still need to maintain strict cost control year-to-year. Given the historical implication and undying fan base attached to the Red Wings, I don't think this sales price is unattainable. Regardless, the bottom line if we were to sell in five years, is that we must rein in costs and accept an offer of no less than $1.5 billion.

Part Three: The Relationship between Player Production and Salary

Data Acquisition: Individual player performance and salary data for all active NHL players during the 22'-23' NHL season were acquired from capfriendly.com. Once again, the data was not in an easily extractable format, so web scraping and crawling was performed on 32 web pages. The data included some variables that were relevant to all players, some that were only relevant to skaters, and some that were only relevant to goalies. For all players, the variables included player name, age, team, games played, handedness, salary, contract clauses, agency upon end of contract, and cap hit. Stats pertaining to goalies alone were wins, losses, shut outs, goals against average, and save percentage. Stats pertaining to skaters alone were goals, assists, points, points per games played, plus/minus, shots, shooting percentage, and time on ice.

Data Filtering and Cleaning: The first step in cleaning the data was separating the goalies from the skaters into their own data set. The goalies were then filtered to only included players with at least one game played and columns with stats only relevant to skaters were dropped. Skaters were then subset into their own data set as well, also filtered to only include players with at least

one game played. The time on ice variables was presented in the minutes to seconds format (i.e., 23:20) and had to be cleaned. To do so, the variables were split into two, minutes and seconds, which were then combined by multiplying minutes by 60 and adding seconds to create a total time on ice in seconds. A time on ice in minutes column was also created by dividing the time on ice in seconds column by 60. For both goalies and skaters, the player name variable included a ranking number based on points in addition to the name (i.e., 1. Connor McDavid), which was removed. All expected numeric variables such as goals, wins, salary, etc., were converted from characters. Finally, the skaters data set was further divided into a defensemen data set and forward data set by filtering for players that contained the letter "D" in their position.

Statistical Relationship: To examine the statistical relationship between player production and salary, the variables used to quantify these metrics needed to be defined. Forwards, defensemen, and goalies were considered separately as success in terms of player production varies in quantity and metrics. In measuring production of forwards and defensemen, points and points per games played were compared. For goalies, average goals against and save percentage were compared. In quantifying salary for all players, actual salary and cap hit were compared. To determine the strongest relationship between the player production and salary, the correlations between the variables were calculated. The results can be seen in Table 5.

Player Type	Variables	Correlation
Forward	Points - Salary	0.72
Forward	Points - Cap Hit	0.74
Forward	Points per Game - Salary	0.69
Forward	Points per Game - Cap Hit	0.71
Defensemen	Points - Salary	0.7
Defensemen	Points - Cap Hit	0.73
Defensemen	Points per Game - Salary	0.62
Defensemen	Points per Game - Cap Hit	0.65
Goalie	Avg. Goals Against - Salary	-0.03
Goalie	Avg. Goals Against - Cap Hit	-0.02

Goalie	Save Percentage - Salary	-0.004
Goalie	Save Percentage - Cap Hit	-0.02

Table 5. Correlations between variables for forwards, defensemen, and goalies in the 22'-23' NHL season with at least one game played.

Both forwards and defensemen were observed to have the strongest relationship between points and cap hit with correlation values of 0.74 and 0.73, respectively. These values indicate that there is a strong, positive linear relationship between points and cap hit. Goalies on the other hand, were observed to have almost no correlation between any variables. As this was a surprising result, further exploration in the data set led to the discovery that almost 25% of goalies played in less than 10 games. Such a small sample size of games likely severely skewed both average goals against and save percentage. Due to this discovery, correlations were recalculated using player data only for those who played in more than 10 games. The results can be seen in Table 6.

Player Type	Variables	Correlation
Goalie	Avg. Goals Against - Salary	-0.11
Goalie	Avg. Goals Against - Cap Hit	-0.09
Goalie	Save Percentage - Salary	0.1
Goalie	Save Percentage - Cap Hit	0.08

Table 6. Correlations between variables for goalies in the 22'-23' season with more than 10 games played.

Filtering of the goalie data set slightly strengthened the correlations with the largest value increasing from -0.03 to -0.11. It can also be observed that the correlations align more with what was expected. For example, we'd expect the correlation between average goals against and salary to be negative and the correlation between save percentage and salary to be positive. However, in Table 5, the correlation between save percentage and salary was slightly negative but has since been corrected with filtering the data in Table 6. Ultimately, the strongest relationship between goalie production and salary is a weak, positive linear relationship.

When considering the relationship between player production and salary, there are some important considerations to be made. First and foremost, as mentioned earlier, entry-level and long-term contracts skew the analysis severely. When a player is being over- or under-compensated for their production, it becomes increasingly difficult to relate the two values. Further, the data set used has no indication of player injury. Rather, the player simply plays in less games. This can be detrimental to the analysis if considering season totals alone. For example, Michael Rasmussen has been an excellent player for the team this year, but due to his injury, has only played in 56 of 82 games. Thus, he only scored a total of 29 points. If we compare his total to Pius Suter's total points of 24, it'd be logical to think they are similar in terms of contribution to the team. However, Suter has played in 79 games this season. When games played is taken into account by comparing the two's points per game played, it becomes clear Rasmussen contributes more with 0.52 compared to Suter's 0.30. Suffice to say, looking solely for the strongest relationship between variables may not provide the most insight into player production. For this reason, moving forward with the analysis, points per game will be used as the player production metric for forwards and defensemen.

Where We Stand: To visualize where the Red Wings stand compared to the league in player production versus player salary, each position's production metric and salary metric were grouped by team and averaged. For both forwards and defensemen, points per game played was used as the production metric, as previously explained, and cap hit was used as the salary metric. For goalies, goals against average was used as the production metric and salary was used as the salary metric. Each set of metrics was plotted against one another, and the results can be seen in Figures 3-5.

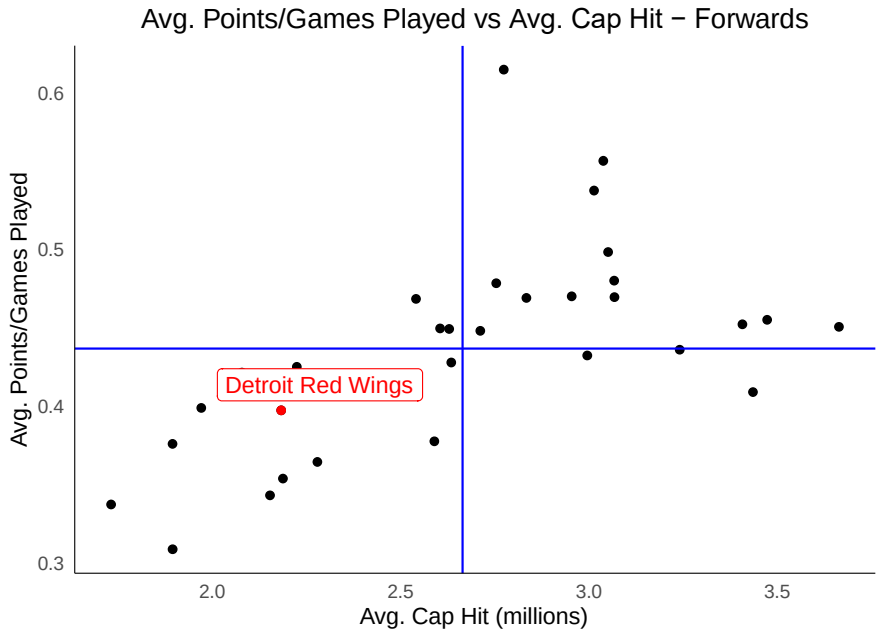

Figure 3. Team average points per games played vs average cap hit for forwards in the 22'-23' NHL season with at least one game played.

The horizontal blue line in Figure 3 represents average points per games played while the vertical blue line represents average cap hit, in millions, for forwards on each team, respectively. The Red Wings are below average in both metrics, suggesting that while we do not overpay our forwards, our player production is lacking. It should be noted that of the teams with a similar average cap hit, the points in vertical alignment with the highlighted red point, we are the most productive. However, there is one team, the San Jose Sharks, with a lower average cap hit but a slightly higher average points per games played. This suggests that while we are the most successful at maximizing player production for our given average cap hit, there is still room for improvement.

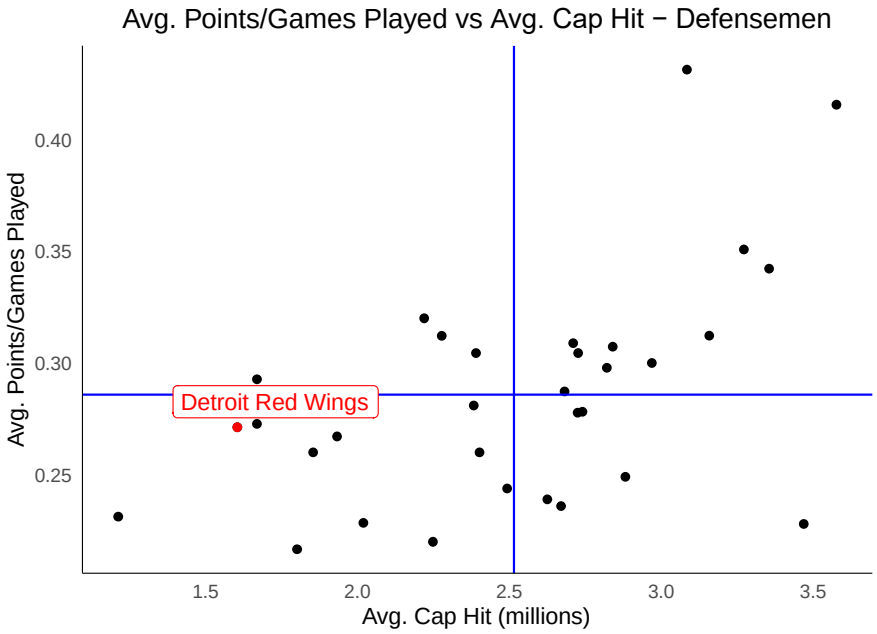

Figure 4. Team average points per games played vs average cap hit for defensemen in the 22'-23' NHL season with at least one game played.

The horizontal blue line in Figure 4 represents average points per games played while the vertical blue line represents average cap hit, in millions, for defensemen on each team, respectively. As with forwards, the Red Wings fall below both metric averages for teams in the league. An interesting observation to note is that we pay our defensemen the second lowest amount, on average, in the entire league only surpassing the Arizona Coyotes. Despite this, our defensemen are more productive than 19 other teams in the league.

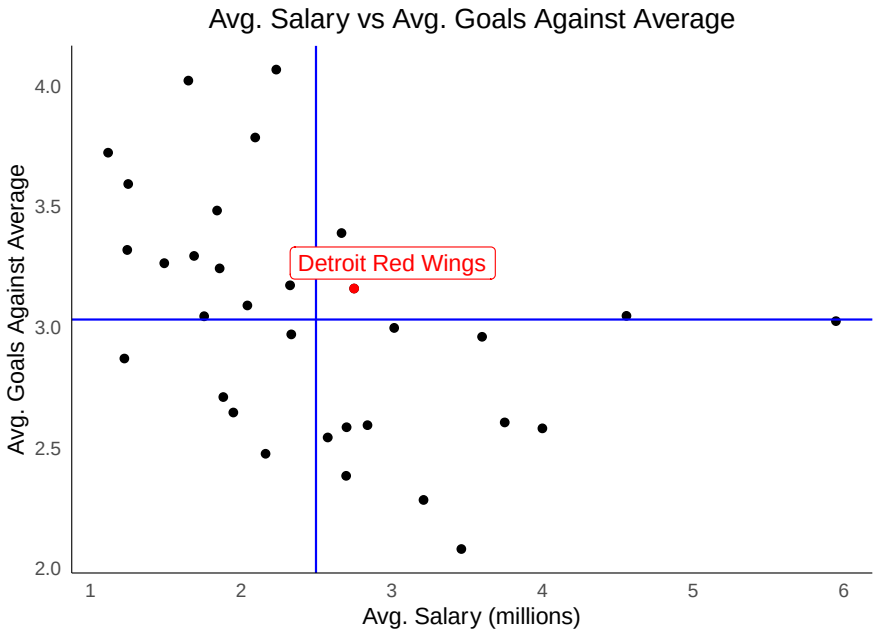

Figure 5. Team average salary versus goals against average for goalies in the 22'-23' NHL season with at least one game played.

The horizontal blue line in Figure 5 represents average goals against average while the vertical blue line represents average salary, in millions, for goalies on each team, respectively. Note that as goals against average is considered more successful with a lower value, it's ideal that goalies fall below the horizontal line versus above it. For this reason, the Red Wings are not in an ideal position in terms of goalie production in salary. We are paying our goalies more than average while they are producing less than average. With that being said, it should be noted that measuring goalie success is extremely difficult for three reasons. First, as we saw in the earlier correlation analysis, there is an extremely weak relationship between production and salary. Second, a goalie's success is incredibly tied to the rest of the team. Unlike other players, a goalie is reliant on their offensive and defensive counterparts to help keep the puck out of the zone and prevent shots. Thus, if the rest of the team plays poorly, it can be unfairly reflected on the goalie. The final reason is that only one goalie plays per game, often in a primary goalie and backup goalie structure. As such, the primary goalie will likely face more difficult opponents which

would potentially decrease their production metrics compared to the backup goalie. With that, I'd recommend focusing on the defensemen and forwards to improve our roster until a more comprehensive analysis can be performed to measure goalie contributions to the team.

Individual Players: To further understand where our roster is lacking, individual player performance was considered. A comprehensive breakdown of individual player stats and salaries compared to the average stats and salaries of their position can be found in Appendix A. As in the previous section, individual player performance will be visualized by plotting production and salary metrics for each position. Goalies were not visualized due to the reasoning presented in the previous section. The resulting graphics can be seen in Figures 6 and 7.

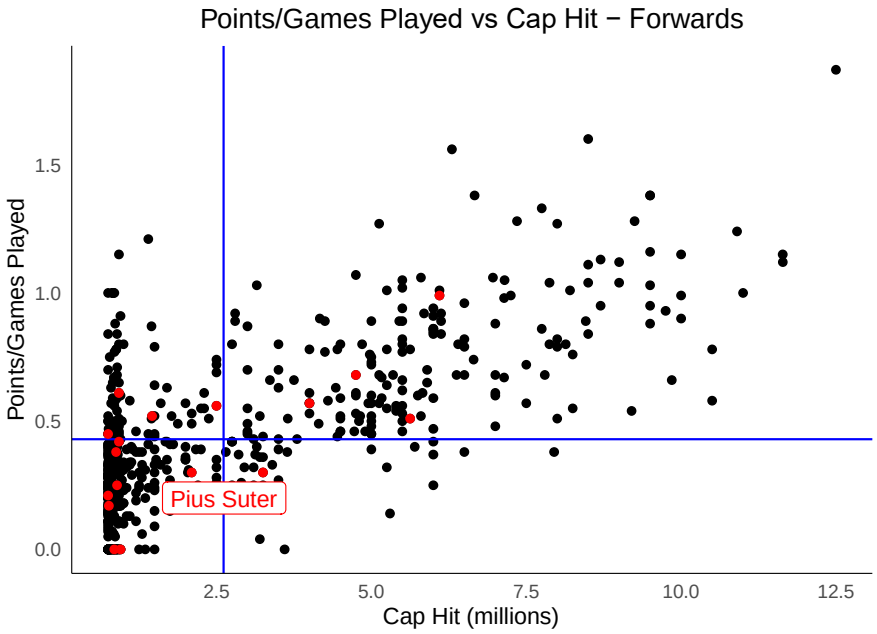

Figure 6. Individual player points per games played vs cap hit for forwards in the 22'-23' NHL season with at least one game played.

The horizontal and vertical blue lines in Figure 6 are representative of the variable means as was observed in Figure 3. Red Wings players are highlighted in the visualization as red points. In evaluating where our player's performance falls on the graph, it's easiest to consider the quadrants of the graph. In the upper right, players are above the average cap hit while also above

the average points per games played. Essentially this quadrant represents those that are worth the additional salary for additional points. In the upper left quadrant, players are below the average cap hit while above the average points per games played. The upper left is arguably the best quadrant for a player to fall in as they are performing very well for less compensation. The lower left quadrant, where a player is below average for both cap hit and points per games played isn't great but isn't bad. These players are producing less but are being paid accordingly. Finally, the worst position on this graph is the lower right quadrant. These players are being paid more than average but are producing less than average. Essentially, they are not producing as would be expected at their compensation level. The only forward who falls into this category for the Red Wings is Pius Suter.

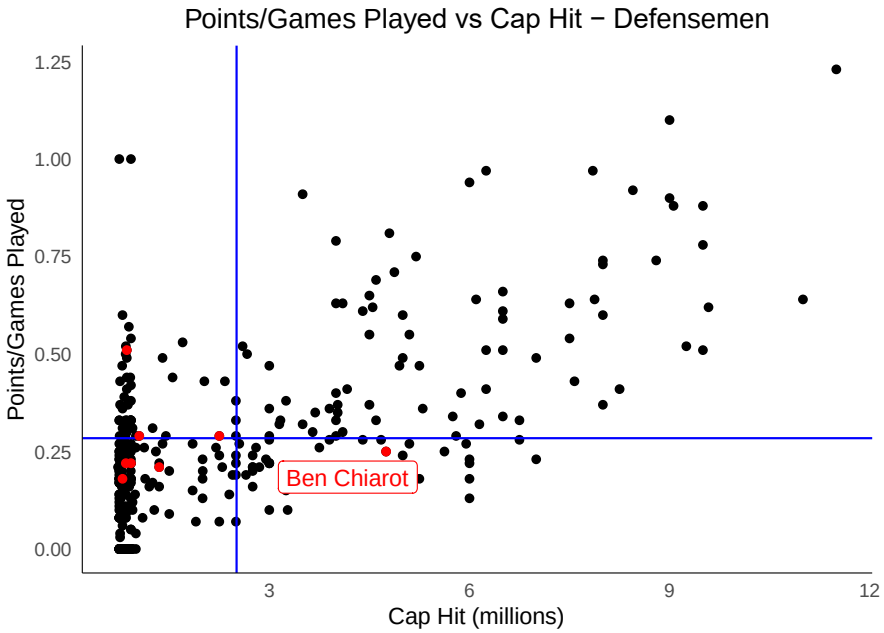

Figure 7. Individual player points per games played vs cap hit for defensemen in the 22'-23' NHL season with at least one game played.

The horizontal and vertical blue lines in Figure 7 are representative of the variable means as was observed in Figure 4. Considering the ideal quadrants, as was laid out for Figure 6, our defense is mediocre. All defensemen but one are paid less than average, but only one is performing

significantly above average, Moritz Seider. A singular player, Ben Chiarot, falls within the worst quadrant on the graph. For the defensemen with the highest cap hit, nearly double the closest behind him, his performance is certainly lacking. Such discrepancies were noted when considering how to upgrade our roster.

Part Four: Upgrading Our Roster

Recommendations: As was noted in the results of the discounted cash flow analysis in part two, in order to keep the organization as profitable as possible, we need to maintain strict cost control. When considering how to upgrade our roster, maintaining current payroll was a top priority. Ultimately, this led to two recommendations based on our performance this past season, one broad and one specific. First, we must continue to seek out young talent and make the most their entry-level contracts. Not only are our younger players boosting team performance, but they are also saving the organization a considerable amount of money. For example, Lucas Raymond's cap hit made up only 2.35% of the team's total last season whereas his points made up 10.3%. With more up and coming young players like Jonatan Berggren, Matt Luff, Elmer Soderblom, and Marco Kasper, to name a few, I'm confident we can maintain our payroll for the next three years to come. Beyond that, however, the scouting team should continue its efforts to maintain the continual flow of younger players coming in to replace those exiting their entry-level contracts.

My second recommendation comes upon completing the player production versus compensation analysis. As was noted in the previous section, Pius Suter and Ben Chiarot are underperforming given their salaries. A look into their individual stats show that they have both played for at least 76 of the 82 games this season, suggesting neither have sustained serious injury to explain their underwhelming performances. Thus, I recommend that we trade these two players next season.

To determine which players to acquire in their stead, linear programming was utilized to solve a constrained optimization problem. A list of names of players who will enter free agency in the 23'-24' season was acquired by web scraping and crawling on capfriendly.com. This list of names was then used to subset the active players data set utilized in part three. This was done to ensure that all the players to be considered have played at the professional level. Filtering was performed on the data that required those considered to have played in at least 41 games, or half a season, so the success metric was not skewed. The data was further filtered to remove players who have a no-trade clause within their contracts. Upon completion of data cleaning and filtering, the constraints for the optimization problem were defined. That is, the program was instructed to identify one and only one defensemen and one and only one forward whose cap hit totaled less than $8 million, the sum of Suter and Chiarot's cap hits, while maximizing points per games played. The optimal solution identified the two players to be Max Domi, from the Dallas Stars, and Erik Gustafsson, from the Toronto Maple Leafs. A comparison of the two sets of players stats can be seen in Table 7.

PLAYER	AGE	POS	HANDED	GP	G	A	P	P/GP
Ben Chiarot	31	LD/RD	Left	76	5	14	19	0.25
Erik Gustafsson	30	LD	Left	70	7	35	42	0.6
Pius Suter	26	C, LW	Left	79	14	10	24	0.3
Max Domi	27	C, LW	Left	80	20	36	56	0.7

PLAYER	+/-	Sh	Sh%	CAP HIT	SALARY	TOI_M
Ben Chiarot	-31	110	0.05	$ 4,750,000	$ 4,250,000	20.6
Erik Gustafsson	9	122	0.06	$ 800,000	$ 800,000	19.8
Pius Suter	-3	106	0.13	$ 3,250,000	$ 3,750,000	14.1
Max Domi	-15	179	0.11	$ 3,000,000	$ 3,000,000	17.8

Table 7. Comparison of 22'-23' NHL season stats between Ben Chiarot, Pius Suter, Erik Gustafsson, and Max Domi.

The optimization results appear to be quite accurate as Erik Gustafsson outperformed Ben Chiarot is every performance stat last season at less than a quarter of the price. When comparing Max Domi and Pius Suter, Domi outperforms Suter in every performance stat last season except plus/minus. This discrepancy could be attributed to the fact that Domi played, on average, 3.7 more minutes a game than Suter. Again, Domi is outperforming Suter, but is being paid less. In total, if this exchange of players were to take place, the Red Wings could save a total of $4.2 million in player expenses while raising their points per games played stats, amongst others.

Limitations: There were two major limitations in completing this report. First, when performing the discounted cash flow analysis, only publicly available data and estimates were used in the calculation. Thus, the anticipated sales price in five years is also an estimate and should be treated as such. The second limitation stems from the constrained optimization problem in the recommendations section. To determine who should be acquired next season, the previous season's stats were utilized. While this achieved the goal of identifying new prospects, last season's stats will likely not be the same as next season's stats for any player. As such, the optimal solutions are limited by the uncertainty of player performance next season.

Future Research and Next Steps: To address the limitations outlined in the previous section, future research is required. Regarding the discounted cash flow analysis, all that will be required to increase the accuracy of the results is collaboration with the team's finance department. Access to financial records will eliminate the need to estimate cash in, cash out, and the cost of capital. The next step to be taken to recalculate the discounted cash flow analysis would be first to determine cost of capital. This will require the finance department to determine and report back the market value of the organization's equity, the market value of the organization's debt, percentage of capital that is equity, percentage of capital that is debt, cost of equity, cost of debt,

and tax rate so that it may be used in the weighted average cost of capital formula (CFI Team 2023).

Future research required to improve the solutions of the optimization problem includes determination of player performance stats that are most reflective of a player's talent and building a predictive tool to estimate a player's success in future seasons based on past seasons. The first step towards both goals would be the collection of at least five previous NHL season's player performance data. By utilizing a larger data set that spans over several years, examination of statistical relationships will be less likely to be skewed. Further, having a measure of a player's performance over several years will help to create a more accurate predictive model. More research will also have to be performed to identify the best-performing machine learning model types in predicting future player performance. With these next steps in mind, I'll only need the cooperation from the financial department. As seasonal data is publicly available, no additional monetary resources will be required to move forward. I am hopeful the future projects laid out here will provide the team with the insight it needs to continue to succeed on and off the ice.

Appendix A

Below are tables containing all players on our current roster broken down by position. For each position, the average of all performance and salary variables was calculated across the league in the 22'-23' season. These averages can be found at the bottom of each table. Each player's individual stats are then color coordinated with the averages. Coloring depends on the logic behind the variable. For example, goals will be colored green if they are above the average whereas goals will be colored red if they are below the average. The opposite is true of variables like cap hit, salary, losses, goals against average, and save percentage where a value lower than the average is preferred.

PLAYER	POS	GP	G	A	P	P/GP	+/-	Sh	Sh%	CAP HIT	SALARY	TOI_M
Dylan Larkin	C	80	32	47	79	0.99	-7	244	0.13	$ 6,100,000	$ 5,250,000	19.6
Andrew Copp	C, LW, RW	82	9	33	42	0.51	2	120	0.08	$ 5,625,000	$ 5,500,000	18.2
David Perron	RW, LW	82	24	32	56	0.68	-7	195	0.12	$ 4,750,000	$ 4,350,000	16.9
Robby Fabbri	LW, C	28	7	9	16	0.57	-1	35	0.2	$ 4,000,000	$ 3,500,000	16.0
Pius Suter	C, LW	79	14	10	24	0.3	-3	106	0.13	$ 3,250,000	$ 3,750,000	14.1
Dominik Kubalik	LW, RW	81	20	25	45	0.56	-15	174	0.11	$ 2,500,000	$ 2,500,000	14.9
Adam Erne	LW, RW	61	8	10	18	0.3	-12	55	0.15	$ 2,100,000	$ 2,400,000	13.4
Filip Zadina	RW, LW	30	3	4	7	0.23	-5	51	0.06	$ 1,825,000	$ 915,000	13.1
Michael Rasmussen	C, LW	56	10	19	29	0.52	2	88	0.11	$ 1,460,000	$ 1,480,000	15.1
Marco Kasper	C	1	0	0	0	0	0	1	0	$ 950,000	$ 950,000	15.0
Jonatan Berggren	RW, LW	67	15	13	28	0.42	-14	98	0.15	$ 925,000	$ 925,000	13.5
Lucas Raymond	RW, LW	74	17	28	45	0.61	-17	134	0.13	$ 925,000	$ 925,000	17.4
Joseph Veleno	C	81	9	11	20	0.25	-12	85	0.11	$ 894,167	$ 832,500	12.8
Elmer Söderblom	LW, C	21	5	3	8	0.38	0	30	0.17	$ 878,333	$ 842,500	12.1
Taro Hirose	LW	3	0	0	0	0	-2	2	0	$ 850,000	$ 850,000	10.3
Austin Czarnik	C, RW	29	3	2	5	0.17	-4	27	0.11	$ 762,500	$ 750,000	11.2
Alex Chiasson	RW	20	6	3	9	0.45	-8	25	0.24	$ 750,000	$ 750,000	12.1
Matt Luff	RW	19	2	2	4	0.21	-4	20	0.10	$ 750,000	$ 750,000	9.9
Avg. Fwd 22'-23'		50.6	11	16	27	0.43	-1.4	96	0.10	$ 2,614,494	$ 2,522,499	13.7

PLAYER	POS	GP	G	A	P	P/GP	+/-	Sh	Sh%	CAP HIT	SALARY	TOI_M
Ben Chiarot	LD/RD	76	5	14	19	0.25	-31	110	0.05	$ 4,750,000	$ 4,250,000	20.6
Olli Määttä	LD	78	6	17	23	0.29	-9	62	0.1	$ 2,250,000	$ 2,250,000	18.7
Jordan Oesterle	LD/RD	52	2	9	11	0.21	-9	54	0.04	$ 1,350,000	$ 1,450,000	15.7

Jake Walman	LD	63	9	9	18	0.29	10	140	0.06	$ 1,050,000	$ 1,050,000	19.7
Simon Edvinsson	LD	9	2	0	2	0.22	-7	5	0.4	$ 925,000	$ 925,000	17.1
Moritz Seider	RD	82	5	37	42	0.51	-11	140	0.04	$ 863,333	$ 832,500	23.1
Gustav Lindström	RD	36	1	7	8	0.22	-16	18	0.06	$ 850,000	$ 950,000	14.2
Robert Hägg	LD	38	2	5	7	0.18	-5	40	0.05	$ 800,000	$ 800,000	15.5
Avg. D-men 22'-23'		48	4	13	17	0.28	1	68	0.045	$ 2,509,951	$ 2,500,719	17.6

PLAYER	POS	GP	W	L	SO	GAA	Sv%	CAP HIT	SALARY
Ville Husso	G	56	26	22	4	3.11	0.896	$ 4,750,000	$ 4,750,000
Magnus Hellberg	G	18	5	8	0	3.21	0.888	$ 750,000	$ 750,000
Avg. Goalie 22'-23'		26	13	10	1	3.09	0.901	$ 2,282,430	$ 2,322,014

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