University of Waterloo
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Process Automation: Tracking Base Metals Financing Trades

RBC Capital Markets

Toronto, Ontario

Prepared by

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Letter of Submittal

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November 21, 2018

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Dear evaluators:

My report, titled “Process Automation: Tracking Base Metals Financing Trades”, was prepared as my 2A Work Report for RBC Capital Markets. This is my first work term report. The purpose of this report is to give a detailed description of the principles behind the automation of tracking daily base metals trading activities at RBC Capital Markets.

RBC Capital Markets is a global investment bank which offers a wide range of services to clients worldwide. In particular, RBC London Branch, with its proximity to the London Metals Exchange, is involved in metals trading,

The Product Control department, at which I am currently employed, is responsible for reporting daily trading Profit and Losses to senior management of RBC Finance. At Product Control, metals trading fall under the management of the commodities team, directed by Michael Prisco. More specifically, the base metals desk, where I have spent most of my time in my co-op term, is run by Mr. Lawrence Brissenden. The base metals desk reports the daily profit and losses of the base metals trading desk located in London, England.

This report was written entirely by me and has not received any previous academic credit at University of Waterloo or any other institution. I received no assistance from others when writing this report.

Sincerely,
Frank Shi ID 20740420

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Executive Summary

This report aims to give a detailed explanation of the principles behind the automation of Base Metals trading data analysis at RBC Capital Markets. Specifically, the analysis is carried out at the Product Control department at RBC, which is responsible for reconciling Front Office and Back Office records.

The report first describes the status quo at the Base Metals desk at Product Control and the necessity to make improvements of the current analysis process. The main portion of the report, however, is devoted to explaining how the automation is carried out by the author of the report using Microsoft Excel VBA. The explanation mostly entails the principles behind the automation, but the report also gives some technical details and calculations regarding the implementation.

Finally, the report describes the risks associated with this automation and some possible ways to improve the product further. These risks include both specific risks associated with the Base Metals desk and general risks of automating an analytical process.

1. Introduction

A commodity is defined as “a product used for commerce that is traded on an organized exchange”, according to the Canadian Securities Institution (2018). An example of a commodity is base metals. According to RBC Dominion Securities (2010), base metals are non-ferrous metals that are not considered precious. Some examples of base metals include aluminium, copper, and nickel. Metals such as silver, gold, and platinum are not considered base metals.

RBC Capital Markets provide financing and storage services to clients who wish to buy base metals. These clients, sometimes referred to as counterparties, are manufacturers, mine financing companies, or metals trading institutions that need to borrow capital from RBC to buy and store large quantities of base metals for a long period of time. From a client’s point of view, it is similar to turning to RBC for a mortgage loan, but the underlying asset is hundreds of metric tonnes of metal, instead of a house (L. Brissenden, personal communication, September 17, 2018).

This business of financing clients to buy and hold metals is called Base Metals Financing at RBC. RBC purchases and stores a specified amount of metal for the client and continues to store the metal until a specified date, called the maturity date, while the client has the option of either demanding the physical delivery of part or all the metals being held, or continue the loan for another period. These two options are referred to as a “buyback” and a “roll” respectively. If all the metals are delivered back to the client, the event is known as a “full buyback”. Otherwise, the event is known as a “partial buyback”. RBC generates profit from Base Metals Financing by charging a premium to the clients on the loans. The premium is analogous to the mortgage interest rate in a mortgage loan.

The Product Control department at RBC Capital Markets are responsible for tracking the daily trading Profit and Losses (P&L). In Base Metals Financing, the daily profits consist of the

premium charged to the clients, and the daily losses consist of the storage rent. The combination of premium and rent is given the name “Gross Economical Value” (GEV). The daily GEV of Base Metals Financing is an essential measure of daily P&L, so Product Control closely monitors the GEV of each Base Metals Financing deal so that they report correct P&L values.

An issue that has caused a great amount of frustration at Product Control’s Base Metals desk is the highly error-prone process of tracking the daily GEV and daily rent of each deal. During August 2018, there have been numerous errors made during data entries, which has a negative impact on P&L reporting: Product Control cannot be completely confident of their daily reported numbers.

There are good reasons why error-prone manual work is required to track daily GEV and daily rent, but a newly found query of live trading positions presents an opportunity to use Visual Basic Application, a programming language used by Microsoft Excel, to automate the manual work in the status quo. This report provides a detailed description of the automation, along with its potential weakness and risks and some ways to combat them.

2. Analysis

2.1. The Current Process

The people at RBC Capital Markets who interact with the clients and book the financing deals are collectively known as the “Front Office”. The database which stores all commodities trading data is called “OpenLink”.

When the Front Office books a trade with a counterparty, the counterparty completes a calculation regarding the trade. These calculations are included in a “Term Sheet”. The Front Office receives the Term Sheets, enters the Term Sheets’ data into OpenLink, and sends the Term Sheets to Product Control.

Immediately upon receiving the Term Sheets from Front Office, Product Control completes two tasks.

1. Complete GEV calculations on the Term Sheets.
2. Input details of the trade into a spreadsheet called a “GEV Schedule”.

These steps are a method to verify that the Front Office has booked the trades into OpenLink correctly. This is important, because in the process of producing the P&L report, Product Control’s report templates import data from OpenLink. These imported data should agree with those on the Term Sheets, otherwise, the reported P&L would not be correct.

When Product Control discovers a disagreement between the Term Sheets and the OpenLink data, they question the Front Office about the authenticity of the OpenLink data. Usually, the disagreement is resolved after Front Office amends the data in OpenLink, and correct P&L amounts are reported to senior management.

2.2. Flaws in the Current Process

Between the two steps that Product Control needs to complete, the second step, i.e. inputting the data into the GEV Schedule, has proven to be highly error-prone. Near the end of September, Product Control discovered that nearly all the live trades booked after mid-August were inputted incorrectly into the GEV Schedule. As a result, the daily GEV and rent given by the GEV Schedule and OpenLink was disagreeing by about 22,000 CAD, a significant amount (L. Brissenden, 2018).

Upon the discovery that the GEV Schedule is corrupted and there was not enough time to fix the mistakes before October, Product Control compared the data between the Term Sheets and data from OpenLink. This verification, although tedious and repetitive, ensured that the OpenLink data imported into the P&L report template was correct, and the discrepancy between the GEV Schedule and OpenLink data was simply ignored.

This reveals two possible areas of improvement at the Base Metals desk.

1. The GEV Schedule is supposed to represent the Term Sheets, but because the inputting process is error-prone, it sometimes does not. Given that we have access to the Term Sheets, is the GEV Schedule really needed to ensure that daily P&L amount is correct?

To ensure that daily P&L is correct, the most essential process involves comparing OpenLink data to the Term Sheet calculation results, but the GEV Schedule is an effective way to collect all the data on live deals so that Product Control does not need to spend the time to access each Term Sheet individually when reconciling against OpenLink.

2. Can the Term Sheet calculations be done automatically?

Performing Term Sheet calculations is a highly repetitive and tedious process. While Product Control has attempted automating this process, they have not succeeded. The main challenge in is the different formats of Term Sheets from different clients. RBC has no control over this lack of standardization. The lack of standardization means the cell location of useful data is different with each Term Sheet, and it takes so much time to write a VBA program that is "smart" enough to detect where the correct data is located such that such approach is simply not worth it (L. Brissenden, personal communication, October 3, 2018).

To summarize, there are two problems with the current process.

1. The data entry into the GEV Schedule is too complex.
2. The Term Sheet calculations are too time-consuming.

2.3. The New Approach

In the beginning of October, upon a request from Product Control manager Lawrence Brissenden, the OpenLink support team created an SQL query so that the position of each live trade can be extracted daily from OpenLink.

An accumulation of daily queries over time can give a complete history of all the live trades just like the GEV Schedule does. Compared to the GEV schedule, the advantage of this approach is that none of the data would be manually inputted. Such accumulative querying of trade positions in fact offers more than the current GEV Schedule. Since OpenLink also gives the information on the Term Sheets, the previously mentioned Term Sheet calculations can be directly using queried data. Thus, proper analysis of queried trading data could render both the Term Sheet calculations and the GEV Schedule obsolete. What's more exciting is that such analysis could theoretically be carried out with a fully automated process in Microsoft Excel with VBA programs.

2.3.1. Finding Relevant Trades

Since the queried data represent a snapshot of the status of each trade, and it is really that change of each trade that interests Product Control, data from at least two days is required to make meaningful statements regarding trading activities. To achieve this, Product Control creates a "Masterfile", called "Master Rate Sheet". A VBA macro in this Masterfile will automatically import the trading data, which is extracted from OpenLink daily, into the Master Rate Sheet.

Importing the data is a rather simple procedure, but some care is taken to label the trades with the day it is pulled from OpenLink (Fig. 2.3.1.1). This is vital, because the trading data in OpenLink changes every time when the client demands a buy or sell the metal. Putting dates on the time-sensitive trading data helps detecting trading activities.

deal_number	effective_date	block_start	block_e	rema	treas	rent_	ltd_	r_mt	ltd_	internal_p	query_date
4474593	09/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
4475798	17/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
4482209	23/10/2018	#########	######	####	###	####	###	###	###	RBCLB BAS	10/26/2018
4492528	22/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
4497204	24/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
4498026	24/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
4498789	24/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
4498807	24/10/2018	#########	######	####	###	####	###	###	###	BASE META	10/26/2018
3923838	15/08/2018	#########	######	####	###	####	###	###	###	BASE META	10/29/2018
3932645	17/10/2018	#########	######	####	###	####	###	###	###	RBCLB CLIE	10/29/2018
4037887	19/09/2018	#########	######	####	###	####	###	###	###	CLIENT FIN	10/29/2018

Figure 2.3.1.1. Data queried on Oct. 26th and Oct. 29th (Oct. 27th – Oct. 28th is a weekend), adapted from *Master Rate Sheet.xlsm*

Dealing with date-labelled trades allows Product Control to focus on the trading events that happened on the query date. This is helped by the "effective_date" column in each trade position (Fig. 2.3.1.1). If the effective date of a trade is identical to the query day, then it indicates that a new trading event has taken place on the query day (Fig. 2.3.1.2).

deal_number	effective_date	block_start_date	block_end_date	remaining_mt	treasury_prem_per_mt	rent_per_mt	ltd_rent_per_mt	rewarrant_per_mt	ltd_settled_rent	internal_portfolio	query_date
4114109	29/10/2018	17/10/2018	19/12/2018	[redacted]						CLIENT FINANCING TOTL	01/11/2018
4114109	02/11/2018	17/10/2018	19/12/2018							CLIENT FINANCING TOTL	02/11/2018

Figure 2.3.1.2. Example of a trading event, adapted from *Master Rate Sheet.xlsm*

The above illustrates a buyback event on Nov. 2nd on deal #4114109. This is a new trading event is because the "effective_date" and the "query_date" columns agree. In this case, the query was performed on Nov. 2nd, and compared to the status of deal #4114109 retrieved on Nov. 1st, that the "remaining_mt" has decreased while the other columns have remained the same. Thus, the conclusion is that a new trading event has occurred regarding deal #4114109.

It is natural then, to use the Excel built-in "Filter" to select all the trading data with the effective date that is equal to the query date. To achieve this, a filter is applied on the "effective_date" column such that all entries where the "effective_date" is equal to the query date are isolated. This gives a list of the deal numbers on which a new trading event has taken place. A dynamic-sized VBA array will then store these deal numbers. Finally, clear the filter on

"effective_date" and apply a new filter on "deal_num", and the parameter will be the pre-mentioned array that stores the deal numbers.

It is much more desirable in general to use built-in Excel features than to replicate them using VBA code. While using a VBA loop to go through all entries of data and checking the effective dates one by one is a theoretically equivalent operation as using the "Filter" feature, the built-in "Filter" is much more optimized. When the size of the dataset becomes large, a VBA loop can cause significant delays.

Using the "Filter" built-in feature presents the first technical challenge of the project: being able to quickly loop through a filtered range of data in Excel. When performing actions on filtered data, the conventional method of looping through consecutive numbers is ineffective, because the filtered entries are located on rows with non-consecutive row numbers (Fig. 2.3.1.3). Below, the blue numbers on the left represents the row numbers of the locations that store desirable data, with row 1 being the column header.

1	effective_date
6	2018-10-23
9	2018-10-23
58	2018-10-23
64	2018-10-23
110	2018-10-23
178	2018-10-23
264	2018-10-23
317	2018-10-23
823	2018-10-23

Figure 2.3.1.3. "Random" row numbers

A solution to this problem is presented in Keith Darlington (2004). It uses a command "For Each cl In rng.SpecialCells(xlCellTypeVisible)…", where both "cl" and "rng" are declared as "Range" objects. The arguments after "rng" restrict the searched field to visible cells only (p. 130). In this fashion, filtered data are accessed directly without using unnecessarily extensive computer memory to go through trade positions.

2.3.2. Categorizing Trade Activities

Once the deal numbers of the new trading events are found, the positions of trades on the day before the query date and one the query date are isolated. This allows Product Control to find and categorize each new trading event that takes place on the query date.

There are four distinct types of trading activities.

1. New deal: RBC finances a client to purchase a specified amount of a base metal. A new deal has a deal number that has never appeared before (Fig. 2.3.2.1).

deal_number	effective_date	block_start_date	block_end_date	remaining_mt	treasury_prem_per_mt	rent_per_mt	ltd_rent_per_mt	rewarrant_per_mt	ltd_settled_rent	internal_portfolio	query_date
4411854	15/08/2018	15/08/2018	17/10/2018	[redacted]						BASE META	16/10/2018
4411854	17/10/2018	17/10/2018	19/12/2018							BASE META	17/10/2018
4414240	14/09/2018	15/08/2018	21/11/2018							RBCLB CLIE	16/10/2018
4414240	17/10/2018	15/08/2018	21/11/2018							RBCLB CLIE	16/10/2018
4414240	17/10/2018	15/08/2018	21/11/2018							RBCLB CLIE	17/10/2018
4475798	17/10/2018	17/10/2018	19/12/2018							BASE META	17/10/2018
4482209	17/10/2018	17/10/2018	19/12/2018							RBCLB BAS	17/10/2018

Figure 2.3.2.1. Example of a new financing deal, adapted from *Master Rate Sheet.xlsm*

Above, both #4475798 and #4482209 are new deals booked on Oct. 17th, 2018. Unlike #4411854 and #4414240, which have appeared in a previous query on Oct. 16th, there are no records of #4475798 and #4482209 before Oct. 17th. This alone is enough to determine that they are new deals booked on Oct. 17th. There are other supporting signs, too, such as the fact that the deal numbers are much larger than the other deal numbers.

2. Roll: a deal matures, but the client extends the contract to a date further in the future (Fig. 2.3.2.2).

deal_number	effective_date	block_start_date	block_end_date	remaining_mt	treasury_prem_per_mt	rent_per_mt	ltd_rent_per_mt	rewarrant_per_mt	ltd_settled_rent	internal_portfolio	query_date
4411854	15/08/2018	15/08/2018	17/10/2018	[redacted]						BASE META	16/10/2018
4411854	17/10/2018	17/10/2018	19/12/2018							BASE META	17/10/2018
4414240	14/09/2018	15/08/2018	21/11/2018							RBCLB CLIE	16/10/2018
4414240	17/10/2018	15/08/2018	21/11/2018							RBCLB CLIE	16/10/2018
4414240	17/10/2018	15/08/2018	21/11/2018							RBCLB CLIE	17/10/2018
4475798	17/10/2018	17/10/2018	19/12/2018							BASE META	17/10/2018
4482209	17/10/2018	17/10/2018	19/12/2018							RBCLB BAS	17/10/2018

Figure 2.3.2.2. Example of a “roll”, adapted from *Master Rate Sheet.xlsm*

It can be determined that #4411854 experiences a roll on Oct. 17th, because the deal number has appeared in the query on Oct. 16th, but the tonnage has not changed from Oct. 16th

to Oct. 17th. Other supporting evidence include the change in treasury premium and rent, as well as the change in block end date and block start date. Note that the block end date in the previous query, Oct. 17th, becomes the block start date in the new query, and the block end date in the new query has been extended to Dec. 19.

3. Partial buyback: the client purchases part of the remaining metals back.

deal_number	effective_date	block_start_date	block_end_date	remaining_mt	treasury_prem_per_mt	rent_per_mt	ltd_rent_per_mt	rewarrant_per_mt	ltd_settled_rent	internal_portfolio	query_date
4114109	28/09/2018	19/09/2018	17/10/2018							CLIENT FIN	09/10/2018
4114109	10/10/2018	19/09/2018	17/10/2018							CLIENT FIN	10/10/2018
4367578	27/09/2018	15/08/2018	17/10/2018							BASE META	09/10/2018
4367578	10/10/2018	15/08/2018	17/10/2018							BASE META	10/10/2018
4417465	10/10/2018	19/09/2018	17/10/2018							BASE META	09/10/2018
4417465	10/10/2018	19/09/2018	17/10/2018							BASE META	10/10/2018
4422821	22/08/2018	22/08/2018	21/11/2018							BASE META	09/10/2018
4422821	10/10/2018	22/08/2018	21/11/2018							BASE META	10/10/2018

Figure 2.3.2.3. Example of a partial buyback, adapted from *Master Rate Sheet.xlsm*

#4114109 has been partially bought back on Oct. 10th (Fig. 2.3.2.3). The most obvious sign of a partial buyback event is the decrease in tonnage. Although this alone usually indicates the nature of the trading event, Product Control also checks whether the treasury premium and the rent has stayed the same, which they should.

4. Full buyback: the client purchases all the remaining metals and closes out the deal.

A full buyback is the same as a partial buyback in nature, except that in the entry that was retrieved on the query date, the “remaining_mt” would be 0.00.

The goal is to automatically go through all the trading events and categorize each event based on the criteria above. This is not a difficult task if the trades were correctly booked, because from a technical point of view, with all relevant information available, the program should work perfectly with a few “If” and “ElseIf” statements in VBA.

2.3.3. Calculations

A benefit of categorizing trading events is that each trading event can be treated with a mathematical procedure such that Product Control can predict the values that will be imported on the P&L reporting day, which is always at least one business day later than the trading day. The data being predicted are not considered to be primary data. They must be calculated. The calculation involved is not complex: it only contains basic addition and multiplication, but the challenge lies with the different treatments that must be applied to different trading events.

The details of the calculations are best illustrated with an example (Fig. 2.3.3.1).

M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
TonnageTraded	TonnageRemaining	DaysBlock	DaysUnused	Premium	ReWarrBal	Spread	PnL	GEVPnL	RentGEV	RentNoN	ReWarrPnL	GEVDaily	Comment
150.000	3000.000	28	7	$10.00	$0.00	$93.25	$13,987.50	**$1,762.50**	$262.50	$12,225.00	$0.00	$5,035.71	Partial Buyback
25.000	50.000	63	7	$10.00	$200.00	$37.85	$946.25	**$285.00**	$35.00	$661.25	$100.00	$81.43	Partial Buyback

Figure 2.3.3.1. A partial table in the calculation tab, adapted from *Master Rate Sheet.xlsm* (data is arbitrary)

In the partial table above, the blue numbers, along with the black numbers in the "GEVPnL" column, are all calculated using Excel formulas. The underlying data of these formulas are summarized below (Fig. 2.3.3.2).

A	B	C	D	E	F	G	H	I	J	K	L
deal_number	effective_date	block_start_date	block_end_date	remaining_mt	treasury_prem_per_mt	rent_per_mt	ltd_rent_per_mt	rewarrant_per_mt	d_	term	query_date
4000001	9/28/2018	9/19/2018	10/17/2018	3150.000	$40.00	$7.00	$83.25	$0.00	#	CLI	10/9/2018
4000001	10/10/2018	9/19/2018	10/17/2018	3000.000	$40.00	$7.00	$83.25	$0.00	#	CLI	10/10/2018
4000002	9/27/2018	8/15/2018	10/17/2018	75.000	$90.00	$12.60	$27.85	$4.00	#	BA	10/9/2018
4000002	10/10/2018	8/15/2018	10/17/2018	50.000	$90.00	$12.60	$27.85	$4.00	#	BA	10/10/2018

Figure 2.3.3.2. Raw data behind the numbers in Fig. 2.3.3.1, adapted from *Master Rate Sheet.xlsm* (data is arbitrary)

Before the calculations are run, a VBA program determines the value in columns M and N in Fig. 2.3.3.1. These two columns are "TonnageTraded" and "TonnageRemaining" respectively, and their values are based on the type of trading event of the particular deal. In the above two figures, both deals #4000001 and #4000002 are partial buybacks. This means that they likely have different values in columns M and N, because the amount of metal bought back usually does not equal the amount of metals remaining. In the case of partial buybacks, the

tonnage remaining is taken directly from the more recently queried row of a deal. For example, #4000001 has remaining tonnage of 3000.00. The tonnage traded would be 3150.00 - 3000.00 = 150.00 tonnes, illustrated in the first row of column M of Fig. 2.3.3.1. The same logic applies to #4000002.

For rolls and new deals, the tonnage traded and tonnage remaining would have the same values.

For columns O to Y in Fig. 2.3.3.1, the methods of calculation are summarized in Table 2.3.3.3. Note that "Col" is a shorthand for "Column".

Table 2.3.3.3. Predicting OpenLink values in columns O to Y of Master Rate Sheet

O (DaysBlock)	block_end_date – block_start_date (Col C – Col D)
P (DaysUsed)	block_end_date – effective_date (Col C – Col B)
Q (Premium)	DaysUnused ÷ DaysBlock × treasury_premium (Col P ÷ Col O × Col F)
R (ReWarrBalance)	TonnageTraded × warrant_per_mt (Col M × Col I)
S (Spread)	Premium + rent_per_mt + warrant_per_mt (if new deal) (Col Q + Col G + Col I) Premium + ltd_rent_per_mt (if buyback) (Col Q + Col J)
T (PnL)	Spread × TonnageTraded (Col S × Col M)
U (GEVPnL)	Premium × TonnageTraded + RentGEV (Col Q × Col M + Col V)
V (RentGEV)	DaysUnused ÷ DaysBlock × rent_per_mt × TonnageTraded (Col P ÷ Col O × Col G × Col M)
W (RentNoN)	rent_per_mt × TonnageTraded – RentGEV (if roll or new deal) (Col G × Col M – Col V) ltd_rent_per_mt × TonnageTraded – RentGEV (if buyback) (Col J × Col M – Col V)
X (ReWarrantPnL)	0 if roll, otherwise warrant_per_mt × TonnageTraded (Col I × Col M)
Y (GEVDaily)	TonnageRemaining × (treasury_premium_per_mt + rent_per_mt) ÷ DaysUnused (Col N × (Col F + Col G) ÷ Col P

There are a few concepts in Table 2.3.3.3 that deserve explanation. The explanations of these concepts are included in Table 2.3.3.4.

Table 2.3.3.4. Explanation of Concepts in Table 2.3.3.3.	
ReWarrBalance (Col R)	The amount needed for the exchange to verify the quality of the metal being stored in the warehouse.
Spread (Col S)	The sum of treasury premium and rent of a metals deal. When there is a new deal, rewarrant fees are also included in the spread. The spread in this context applies to one metric tonne.
RentGEV (Col V)	RBC makes interest profit on part of the rent. That part is called RentGEV.
RentNoN (Col W)	The part of rent on which RBC does not make an interest profit is called RentNoN.
ReWarrantPnL (Col X)	This is equal to ReWarrBalance
GEVDaily (Col Y)	Perhaps the most important metric in the Master Rate Sheet. This indicates the daily premium profit received by RBC on each deal.

No documentation currently exists as a reference to the calculation methods in Table 2.3.3.3. Much of how the calculation methods were discovered includes speculation and making educated guesses. The speculation arose as a necessity at Product Control to make sense of what OpenLink is doing with the raw data. However, speculation it may be, the calculation methods listed in Table 2.3.3.3 has been agreeing with OpenLink data for years. (L. Brissenden, personal communication, October 17, 2018). It is therefore safe to assume their correctness.

The concept of warranting deserves a further remark. When base metals are purchased through the London Metals Exchange, the LMW charges a fee, which they use to ensure the quality of the metal being bought. The same fee is also charged when clients buy back the metal, because the quality needs to be re-assured before delivery. Warranting is important because the purity of a large quantity of metal dramatically impacts its value in manufacturing. A block of aluminum with a high purity has a higher per-metric-tonne price than a block of aluminum that has a lower purity (D. Bimo, personal communication, Oct. 17, 2018).

The warrant fee is a necessity when any new deals are booked with RBC, or if there are any buybacks, but they are not needed when a deal is being rolled. This is because when a deal is being rolled, the underlying metal has already been verified by the exchange before. Thus, in the calculations in Table 2.3.3.3, the rewarrant balance in the event of a roll is zero.

With the calculations complete, Product Control effectively has the power to get a complete picture of base metals P&L on the same day of the trading day instead of the next business day. However, there are risks associated with such benefits, outlines below.

2.4. Risk of the New Approach

The laws of the new approach generally belong to two categories: risks associated specifically with the Base Metals desk, and risks associated with automation in general.

2.4.1. Risks Specific to the Base Metals Desk

By bypassing the Term Sheet calculations with the Master Rate Sheet, Product Control no longer has the need to inspect the Term Sheets of each new trading event. While this saves a great deal of time, it also takes away the opportunity for Product Control to verify that the information booked into OpenLink matches the Term Sheets.

This verification is the primary method to identify Front Office booking errors. While Product Control can anticipate some common types of booking errors and write VBA programs in the Master Rate Sheet to detect booking errors, this cannot guarantee to detect all booking errors. Thus, by abandoning the term calculations and relying on the Master Rate Sheet only, Product Control is assuming that the data entered by the Front Office into OpenLink agree with the Term Sheets. This is not always the case.

The most serious consequence of data disagreement between Term Sheet data and OpenLink data is the possibility that the Front Office not reserving enough rent payable to the metal exchange, which provides storage for the metal. This can create unexpected losses at the

end of a financing deal, which in turn hurts RBC's profits as well as the compensation of Front Office Base Metals traders.

The best way for Product Control to avoid Term Sheet disagreements is to manually verify the booking of each new trading event with respect to the Term Sheets, but this would of course defeat the purpose of building an automatic Master Rate Sheet. A possible solution is to urge the Front Office to validate the booking of new trading events so that the OpenLink data do agree with the Term Sheet numbers. Such a validation team in fact already exists, but it still has not prevented booking errors slipping through.

Besides surrendering the opportunity to compare Term Sheets and OpenLink data, no other major flaws of the Master Rate sheet has yet represented themselves. However, there are a larger number of risks of abandoning the old process, and these problems are associated with the general risk of any kind of automation.

2.4.2. General Risks with Automation

The VBA programs behind the trading data analysis in the Master Rate sheet are not complex in principle, but the VBA code that make up all the procedures in the Master Rate Sheet currently consist of about 1000 lines of code. Although the size of the program can be reduced by optimizing the code, the essentials of the VBA procedures will still be substantial. Two potential risks arise from the complexity of the spreadsheet.

2.4.2.1. Concealing Calculations

While automation is aimed at reducing manual work, developers and programmers commit human errors in the process of implementing automation. The End User Computing Module at RBC (2018) correctly points out such human errors are both "hidden and magnified by the complexity of tool".

The upside with computer programs is that continuous use and testing can reveal the programmers' errors. Once these errors are fixed properly, no further corrections are required. However, even this advantage is hampered, because when the program is developed by a co-op student who is only working at RBC for four months, testing time is limited to little more than two months. This increase the risk of leaving behind a faulty program that can cause mistakes.

There are some ways to combat this. Elaborate documentation helps. With more and more students being proficient at VBA programming, maintaining a rather extensive macro-enabled spreadsheet is made rather easy with a detailed explanation of the principles behind the spreadsheet's design. After all, all members of the commodities team at Product Control successfully use macro-enabled workbooks to perform daily P&L reporting, and some of these workbooks were created almost a decade ago.

Nonetheless, the Master Rate Sheet contains some degree of analysis and decision-making such as categorizing, which in turn impact calculations. This is generally not seen in the accounting books that most of Product Control uses. Detailed documentation is still a very necessary step to ensure that the spreadsheet can continue to be used for the future convenience of the Base Metals desk.

2.4.2.2. Lack of Validation

Another risk associated with automation in general is that people tend to trust the results given by programs in the long run. Such reliance on programs can reduce people's vigilance in checking the results.

Such phenomenon is not uncommon among Product Controllers who daily rely on macros in performing their tasks. When problems occur with a database or an application, Product Controllers' Excel spreadsheets stop functioning properly. In these instances, manual operations

can enable people to continue with their work, but often, Product Controllers forget how to perform tasks manually.

At the moment, it seems very straightforward that, if the Master Rate Sheet stops working, the Base Metals desk can just revert to checking the Term Sheets of each new trading event. It is uncertain, however, whether people still know how to correctly interpret Term Sheets if the Master Rate Sheet becomes the norm at the Base Metals desk. This is assuming, of course, that the Master Rate Sheet is in fact good enough to be used extensively in the future!

In summary, the lack of validation after automation takes place is a general risk associated with automation, and the Master Rate Sheet is no exception.

3. Conclusion and Recommendations

At the moment of writing, the Master Rate Sheet is capable of replacing the daily tasks such as Term Sheet calculations, but the risks remain. It is now appropriate to give some suggestions regarding how to reduce the risks that are associated with using the Master Rate Sheet in place of the old process.

3.1. General Risks of Automation

The risks mentioned in section 2.4.2, namely, the risks of concealing calculations and lack of validation after implementation of automation, are almost unavoidable. However, there are some ways to reduce losses as much as possible.

Product Control can periodically perform spot checks to make sure that the manual processes are yielding the same results as the automated VBA programs. This may not sound like much, but it is in fact surprisingly effective. Specifically, as Front Office keeps sending Term Sheets to Product Control, there are many chances to perform manual calculations on Term Sheets and compare the results with those generated by the Master Rate Sheet. Additionally, the

Front Office keeps their own version of a GEV Schedule, which provides another chance at reconciliation.

Of course, the problem remains that if an error is ever discovered after the developer of the Master Rate Sheet leaves RBC, the error might be challenging to fix. This is where well-documented VBA code becomes helpful. Beyond that, however, there is not much that can be done.

If Product Control ever feels the need to abandon the Master Rate Sheet completely and return to the old process, there are still some room for automation, but the possibilities are not on the same level as the Master Rate Sheet. These automations are small shortcuts that automate simple operations in Microsoft Excel. These operations include inserting a copied row, copying by value, copying by value only and transposed, and automatically generating the table used in Term Sheet calculations. The developer of the Master Rate Sheet has written VBA programs for these operations such that, even if the Master Rate Sheet is an eventual failure, the old process will still be more efficient in the future.

3.2. Risks Specific to the Base Metals Desk

In section 2.4.1, it is identified that the Master Rate Sheet takes away the opportunity to verify trading data against Term Sheet data, thus effectively assuming that all trading data in OpenLink to be correctly booked. Although the history of Front Office booking errors shows that this is not a strong assumption, Product Control do have the power to ask the Validations department in the Front Office to pay more attention to the bookings.

In short, if the OpenLink bookings are correct, the Master Rate Sheet should work without any problems. The dichotomy between human error and the perfect execution of computer code makes perfect automation of the Base Metals desk particularly challenging. This might even be true in the general world of automation.

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