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USING MARKOV CHAIN TO FORECAST SALES BOOKING

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Maneesh Bhandari, Pramod Kumar Bagri and U Dinesh Kumar, Professor of Decision Sciences and Information Systems, prepared this case for class discussion. This case is not intended to serve as an endorsement, source of primary data, or to show effective or inefficient handling of decision or business processes.

'We Sell Everything in Software' (WSES) Inc was a products company and specialized in software solutions for different industries such as defense, clinical research, consumer goods, capital markets, security, banks, and insurance among others. One of the divisions of WSES focused on enterprise software product. Over the last one decade or so, competition in the enterprise software product space had intensified and in response to increasing competition WSES had changed the way it was dealing with new opportunities. Customers in the meantime had also matured and they were demanding integrated contracts–software product along with after sales support. As a result of this ticket size, the average value (of an opportunity or contract) of opportunities had increased and so had the stakes.

WSES's CEO Jack Williams was under increasing pressure from stakeholders to provide more accurate numbers to the street for enterprise software product division. A month earlier when Jack had faced the stakeholders, he had found it difficult to explain to them the reason for high variation in revenue numbers. Jack had predicted that WSES's Enterprise Software Product division would close new sales of USD 2.4 billion in the quarter, whereas the actual new sales booking was only USD 1.48 billion. He had a heated discussion with Michael Summers, the CFO on this and Michael had mentioned that this was something which was not in his hand. Michael was taking the numbers from Ben Osborne, Vice President Marketing at WSES and these numbers served as guidance to the street.

Sitting in his room on February 8, 2018, Jack had a telephonic conversation with Ben to understand the process by which Ben was giving estimates of revenue from new sales.

> Jack: I want to understand how you give estimates and why we are so much off the mark every quarter.
>
> Ben: Our conversion of new sales into revenue is a complex process. What we do is that we look at last quarter of sales, and add our estimated increase of 1.5% to it. This is the number which I provide to Michael as an estimate.
>
> Jack: But this is not scientific. Why do you add 1.5% to last quarter's sales?
>
> Ben: Our industry's average growth is 6% per year and hence we add 1.5% to last quarter's sales. I agree that this is not a scientific method but this is the best we have as of now.
>
> Jack: I think we need help here. Not predicting conversion of new opportunities is not only hurting our image in front of stakeholders but I am also hearing some noise from the delivery and deployment team that they are not able to manage the staffing and planning since these contracts require resources to customize the products for the customers.

Jack then remembered meeting Mark Smith a few weeks back. Mark had a PhD in Statistics and had joined WSES recently. Mark had rich experience in analytics and Jack called on him to see if Mark could help him solve this problem.

The next day, February 9, 2018, Jack and Ben met with Mark and explained to him the problem and their sales process. WSES's new sales opportunities passed through three stages before the contract was signed with customers.

Stage A: Request for Proposal (RFP) initiation and reply

Stage B: Commercial discussion and shortlisting

Stage C: Contract discussion

They explained to Mark that every new opportunity was added into their global sales management system and as the opportunity moved through the stages of opportunity; the status was updated in the system. He was also informed that in many cases, customers decided to either withdraw the opportunity in one of these stages or award it to their competitors. Successful opportunities which were converted into sales were those which went through all the three stages and culminated in the 'contract signing' stage.

DATA COLLECTION AND RELEVANT ANALYSIS

Honored but intimidated by the task, Mark first researched the available data. He logged onto WSES's global sales management system and collected data for the last 4 months (October to January 2017) for the Enterprise Software Product division. He found the number of data characteristics overwhelming but then realized that he would not need all these characteristics (refer to **Exhibit 1**).

Looking deeply at the data, Mark realized that some part of the opportunities in each stage was moving to the next stage in the following month. Some part was remaining in the same stage and the remaining part was getting lost (either the customer was withdrawing the opportunity or had awarded it to a competitor). Mark felt that the structure of the problem could be modeled using Markov chain. He then decided to create a transition probability matrix to represent the structure of the opportunities that were moving across different stages. Mark's idea was to use absorbing state Markov chain to predict what percentage of opportunities would get absorbed as 'contract signing' and what percentage would get absorbed as lost. This would help him predict the revenue depending on what value of opportunities was in every stage in a given month. For each of the months, he created a transition matrix and thus ended up with three transition matrices. Each state represented the status of opportunities moving across the stages in each month and gave him a view of what percentage of the opportunities was getting absorbed as 'contract signing' and what percentage was getting absorbed as 'lost or withdrawn'. He could also see how opportunities were moving between the stages in each of the months.

Mark then used the three transition matrices (constructed using four months data) to create an aggregate matrix (refer to **Exhibit 2**), and used Anderson Goodman[1] test to check if the matrix was a Markov matrix. The test proved that the matrix in question was a Markov matrix. His next step was to check whether the three matrices for each of the months were time homogeneous, and he used likelihood ratio

[1] Anderson Goodman test is an hypothesis test to check whether the transition matrix is a Markov matrix.

test[2] to check the same. He did this to ensure that there was no statistical difference between the transition matrices in each of the months (October to November, November to December and December to January) so that he could create an aggregate matrix from the three matrices.

Armed with the data and test results, he then did the calculations and arrived at what percentage of opportunities in each stage would get converted into revenue. He also calculated the amount of time that the opportunities in each of these stages would take to get converted into sales booking.

Mark then requested for a meeting with Jack and Ben to discuss this.

Mark explained to Jack and Ben that not only could the model predict what percentage of opportunities in each stage would get converted into contracts, his model could also predict the amount of time that the opportunities in each stage would take to get converted into contracts. He then took some examples to explain the concept and detailed workings to Jack and Ben.

Jack was very excited to see the results.

"Excellent, this is exactly what we needed. Let's start using this to predict our revenues for new sales and also please start using these numbers to give forecast to planning team'' remarked Jack to Ben.

[2] Likelihood ratio test checks whether the Markov matrix derived based on different time periods is homogeneous.

Exhibit 1

Data fields used from the available data

Opportunity Id.	S. No. of the opportunity
Customer name	Name of the customer
Product type	Name of the product
Region	Includes the following regions of the client: Africa Australia Canada The Americas Other Europe Middle East Singapore India Japan Spain UK
Opportunity value	Dollar value of opportunity in USD million
Stage	Stage of opportunity in a particular month Stage A: RFP initiation and reply Stage B: Commercial discussion and shortlisting Stage C: Contract signing Lost: Lost or withdrawn by client Won: Contract signed with client

Source:

Exhibit 2

Aggregate data (all values in USD million)

Aggregate data (all values in USD million)						
	Lost	**Stage A**	**Stage B**	**Stage C**	**Won**	**Grand Total**
Lost	1,737					1,737
Stage A	457	1,119	614			2,190
Stage B	272		715	895		1,882
Stage C	859			571	561	1,991
Won					544	544

Exhibit 2 (Contd.)

Aggregate matrix						
	Lost	**Stage A**	**Stage B**	**Stage C**	**Won**	**Grand Total**
Lost	1.000	-	-	-	-	
Stage A	0.209	0.511	0.280	-	-	1.00
Stage B	0.145	-	0.380	0.475	-	1.00
Stage C	0.431	-	-	0.287	0.282	1.00
Won	-	-	-	-	1.000	1.00

Source: