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WHITE PAPER

Discrete Choice Modeling for Diagnostic Tests

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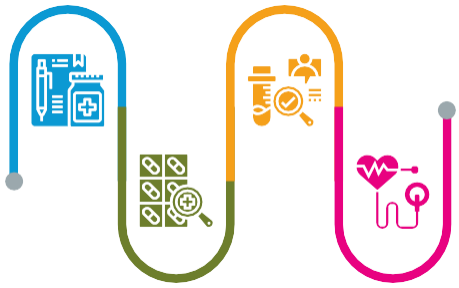


Mathematical models of “discrete choice” for commercial purposes.

Commercializing a product takes a lot of effort and investment. In recent years, mathematical models have played an important role in product development and the essential processes of moving it from development to the market. Using an example diagnostic, we will show how mathematics can improve its commercialization.

The Discrete Choice Principle

A discrete choice is an informed decision involving the selection of one product from a finite number of competing products. Selection criteria take the **characteristics** of each product as well as those of its competitors into account. A mathematical model of discrete choice **assigns each product a probability of being chosen** (a preference share) in relation to each ofthe competing products.

To build our models, we collect data of physicians’ choices when they are deciding which alternative diagnostics, therapeutics, or medical devices to use for dealing with a patient’s health issues.

Where Discrete Choice Fits

During the pre-market life of a product, it will have a set of characteristics (attributes and levels). Consider the example in Table 1.:

Example Diagnostic

Attribute	Level
Sensitivity	90% to 98%
Specificity	70% to 80%
Material to be tested	Whole blood
Test Turn-Around Time	3 days to 2 weeks
Test Report Format	Report Pos/Neg only, Report Ranges
Patient Price per Test	$25 to $200

Table 1

In Table 1, the characteristics shown in green are developed in the lab. In this example, the lab has proposed ranges for some attribute levels that can change based on the amount oftime and money available for development.

In addition to a diagnostic's lab-based characteristics, there are several decisions a company must make to commercialize the product. These include decisions on which Test Report Format to use to show the physician's test results and what Price to charge for the test.

Discrete Choice modeling can help answer critical questions, such as:

- How much should the diagnostics company invest in optimizing Sensitivity?
- Is Specificity more or less important than Test Turn-Around Time?
- How can we be confident that we can charge a high enough price to recoupour investment without losing market share?

The answers can help determine the probability of choosing one test over competing tests -based on all of its characteristics and those of its competitors and fortify the businessdecision.

The Model

The discrete choice mathematical model is of the following form. Given adecision-maker (e.g., a physician), d, and a product, p.

U_{dp} = the "utility" decision-maker d has for product p = V_{dp} + e_{dp}

Where V_{dp} = some function of (tastes of decision-maker d, attributes ofproduct p) = V(T_d , A_p)

And e_{dp} = the governing error probability distribution due to factors not included in V(). The form of edp is most frequently assumed to be Logit.This assumption has implications for how the model behaves.

In many applications V_{dp} is simply the sum of the values placed on each attribute level by the decision-maker. The preference share can be calculated from the U_{dp}, depending on the form of the error probability distribution.

Practicalities

Designing a discrete choice model requires an interdisciplinary team familiar with all aspects of theproduct and the market in which it will compete. A well-defined model must represent the arrays of characteristics of *all* the current and future competing diagnostic products. The model will use the physician's responses to a number of relevant questions. Since a survey respondent will give usno more than 45-minutes of their time, the model must tune the number of attributes, levels, andtheir complexity to deal with that.

The context in which a physician is making decisions may well influence the relative values they place on various characteristics. This means that we must carefully define the relevant contexts and build a model for each one. The context is usually related to the description of the patient disease state. For example, when choosing a diagnostic to detect bacteria, the context could be a patient with an infection that may be septic. The value of fast turnaround for a blood test for bacteria may be very important for this patient, but less so when the context is a patient with a lesslife-threatening infection.

Fitting the Model

To fit the model, we recruit a sample of physicians to a specialized survey designed to elicit Vdl, the values for physician d, of all attribute levels, l. In our experience, the best survey methodology forces a physician to make a choice in which they will have to trade off the values of multiple attributes. These forced choices, because of the trade-offs, typically yield V's that are less tightly bunched and more realistic than simple rating schemes tend to. Figure 1 is an example of a forced choice question.

Please examine the hypothetical diagnostics described on the left and right.
Then select your preference level below.

You can assume that any characteristics NOT shown are identical for both tests.

Diagnostic Test I			Diagnostic Test II	
Sensitivity: 90%			Sensitivity: 90%	
Specificity: 70%			Specificity: 80%	
Material To Be Tested: Whole Blood			Material To Be Tested: Plasma	
Patient Pricer per Test: $100		*versus*	Patient Pricer per Test: $50	
Test Report Format: Report Pos/Neg Only			Test Report Format: Report Test Metric Ranges	
Specialist Opinion of the Test: Neutral			Specialist Opinion of the Test: Does Not Recommend	
Strongly Prefer ☐	Somewhat Prefer ☐	No Preference ☐	Somewhat Prefer ☐	Strongly Prefer ☐

Figure 1

In the past, surveys based on a fixed experimental design were used to determine which forced choices would be shown to the physician. Modern methods do not use a fixed design, but rather adapt them- selves to the respondent. Accordingly, Rosa's model creates each new forced choice from an on-the-fly analysis of the stream of answers to the previously posed forced choice questions. The responding physician is asked to state the degree to which they prefer one or the other of the two offered choices.The forced choice flow is outlined in Figure 2.

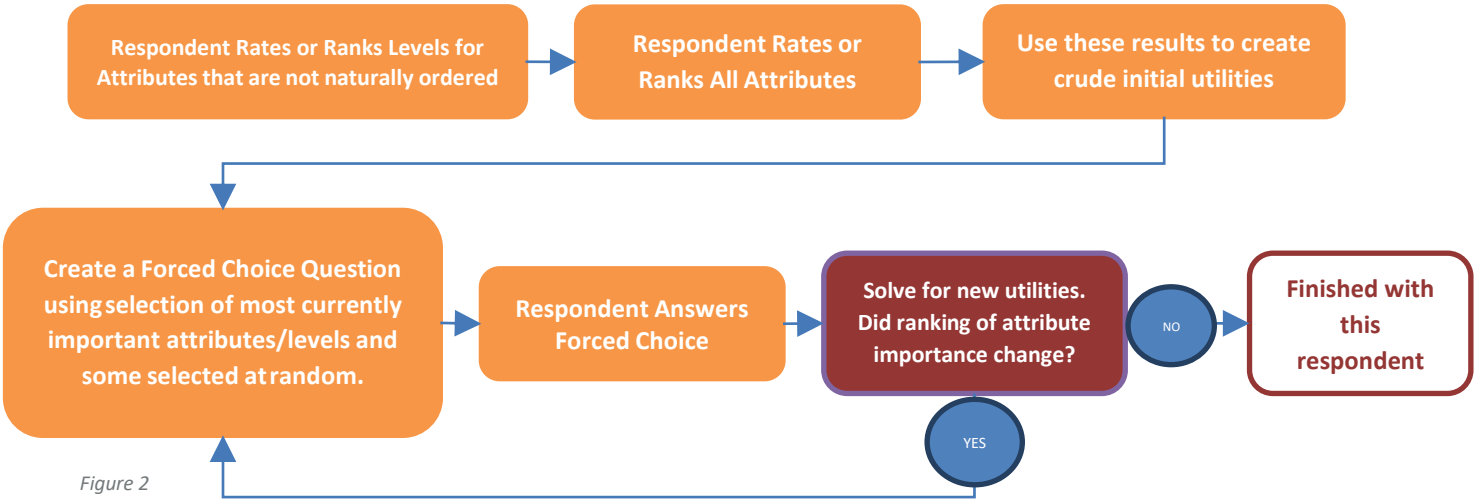


Figure 2

Simulation

Having computed the utility estimates for all attribute levels for each respondent, Rosa's models cansimulate a marketplace of the respondents, offer them competing diagnostics, and calculate the preference share of specific diagnostics for each respondent and for the aggregate. Thus, our simulations can show how much product share changes for each modification in its characteristics or its competitor's characteristics. Figure 3 shows three such diagnostics defined to investigate their preference shares.

Product Scenarios				
Product Name	Test 1	Test 2	Test 3	
Include product in a model run?	Yes	Yes	Yes	
Color on graphs				
Starting Values				
Product Launch Year	2018	2021	2022	
Known Share End 2020	60%	0%	0%	
Static Attributes				
Sensitivity	90	90	95	
Specificity	85	80	85	
Material do be Tested	Plasma	Plasma	Whole Blood	
Report Format	Report Pos/Neg Only	Report Pos/Neg Only	Test Metric Ranges	
Specialists Opinion of the Test	Neutral	Neutral	Recommends	Compute Shares
Dynamic Attributes				
Patient Pricer Per Test	$50	$100	$150 in 2022 $100 in 2023	

Figure 3

Figure 4 shows the dynamic preference shares resulting from respondent utilities we measured, andthe characteristics of the three competing diagnostics. Since these shares are based on models of real physicians, and we can explain how much each diagnostic's characteristics contribute to these shares, these results can be used as scientifically defensible inputs to financial models.
Our clients have used the findings from our models for internal discussions about product planning and strategy as well as for external discussions with investors and partners to convey the commercial potential for their test.

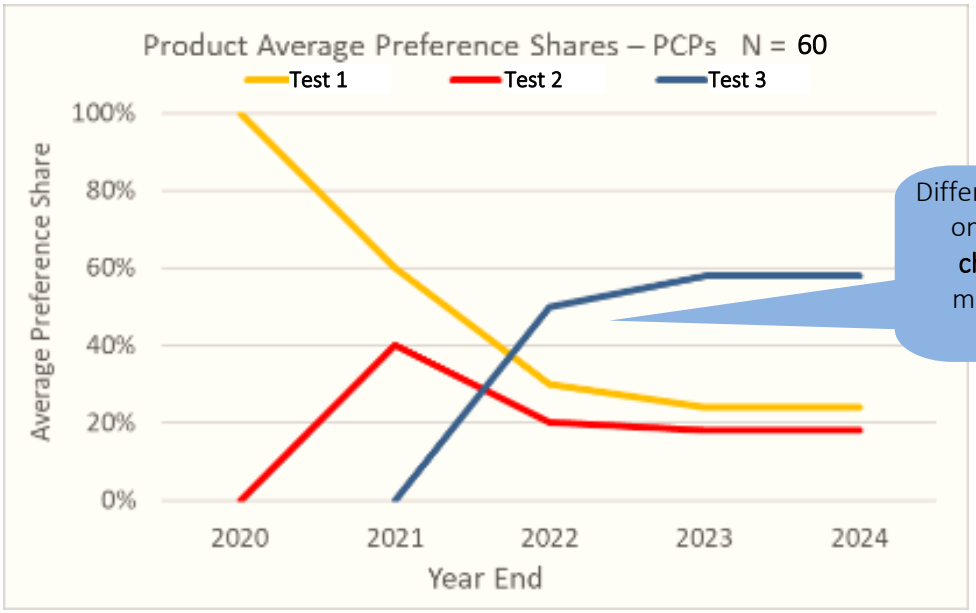


Figure 4

Our clients receive the survey results in an easy-to-use Excel-based simulation model that allows them **to analyze shares due to changes to their own products or the products of their competitors**.

Because of the direct link from measured physicians' opinions and product characteristics, discrete choice market models are more accurate, credible, transparent, and durable than traditional black box approaches.

- **More accurate**, since a physician's probability of choosing a particular product is directly related to the **measured** importance they place on each product characteristic.
- **More credible**, because this physician dataset can be used to explain exactly how the market model **shares relate to differing physician opinions** and differing product characteristics.
- **More transparent**, since the Excel-based market model is an easy-to-use dashboard into the physician dataset and changes made to product characteristics yield changes in share.
- **Durable**, because the market model can be used repeatedly to explore changes in the market as they develop, without having to re-survey physicians.

Implementing the Findings

Our clients can use the Market Model results to support both **internal and external communication** about their products in discussing product design, commercialization, funding, and partnering.

Analyses showing **product characteristics and the resulting potential shares** can be used to inform internal **product design** discussions regarding, for example, the most profitable efficacy targets to aim for. Share results can also answer commercialization questions around **pricing and logistics as well as go/no go decisions** with a company's Board of Directors.

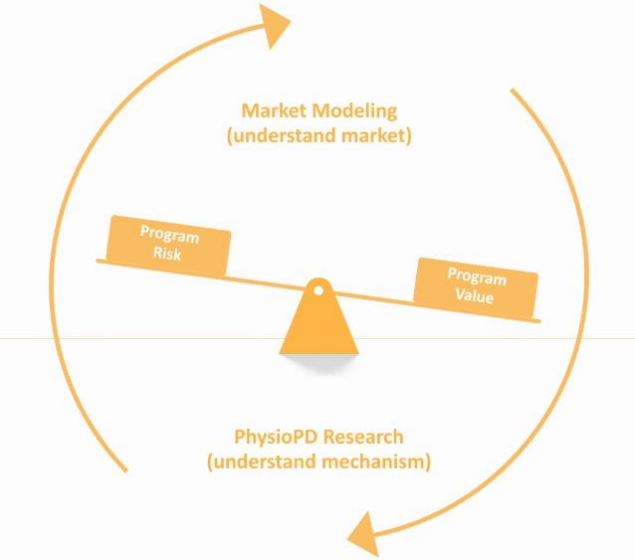
The results can also be used to inform external discussions with **prospective investors and partnering companies** to demonstrate the potential demand for the product.

Summary

Quantitative discrete choice models give companies the ability to predict how their asset's performance on key product attributes will impact demand by physicians. A **quantitative discrete choice model can quantify physician preference for your product versus its current and future competitors**. Results from these studies can be used during internal discussions about product planning decisions as well as external discussions with investors and partners regarding the market potential for your asset.

Rosa Market Modeling

For 20 years, Rosa Market Modeling has been delivering insights that are difficult if not impossible to achieve through any other way. Using advanced applied mathematics-based tools, our models are transparent,dynamic, and individually tailored to a specific product, therapy, or diagnostic. Furthermore, they cover a wide range of factors, including product development, product design, and promotional methods. To answer each client's needs in the complex world of commercialization, our models consider complex interactions between relevant factors within a wide variety of competitive scenarios. Rosa Market Models are the antidote to traditional, unrealistic, overly optimistic revenue forecasts and provide concrete evidence for your business decisions.



About The Author

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As the Chief Technology Officer of Rosa's Market Modeling practice, Dr. Brastow specializes in the design and implementation of customized market research surveys, physician choice models, and dynamic market models for biopharmaceutical and diagnostic companies

Want to know more, or have a demo, please contact

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