



15.879 Advanced System Dynamics Modeling

Spring 2025

Exercise 8- Diffusion with Endogenous Scope and Quality

Submit your model to the shared dropbox before the class on Friday 4/11/2025

While typical diffusion models look at the spread of a single, unique product, in reality many firms improve their product(s) over the product life cycle, and thus impact the diffusion dynamics endogenously as people learn about the utility of the product and start to use the product for more extensive applications, increasing its scope of use. For example, consider pacemakers. These devices were first introduced in the 1960s, and have since improved significantly in size, safety, longevity, precision, and customization, to name a few. These improvements, fueled by significant R&D investments, have made pacemakers useful for a wider and wider set of symptoms. This exercise provides you with the background needed to build a simple model capturing this diffusion process. The problem statement is developed based on research and models developed by Jack Homer for his Ph.D. thesis.

The adopters include the fraction of the total population with any use case related to product (e.g. any kind of heart problem in pacemaker case) who are using the product. This fraction depends on the scope of use of the product, e.g. what fraction of all potentially relevant uses the product is applicable to. For example whether pacemakers are only useful for dangerously ill patients, or a wider population group may benefit from them. Another determinant of use is the perceived utility of the product (i.e. if people think the product fully addresses the need, or there are significant side effects or questions about its efficacy). For example, pacemakers were originally only used for the most severe heart problems, but as they became more effective, their scope of use has expanded to many minor heart conditions as well. On the other hand, while for the most acute cases a pacemaker is a must, and thus almost always applied, in many more marginal use cases the perceived utility is lower and thus some potential users may opt not to implant a pacemaker. In essence, the scope sets a maximum potential user base, which then, depending on the perceived utility of the product (for that scope), may or may not be realized.

On the other hand, new users will adopt the product faster (i.e. have lower “Time to Adopt”) if there are more adopters in the market because current adopters increase access to the information regarding the availability and the usefulness of the product.

Scope of use largely depends on the underlying technological capabilities of the product. Those features and functionalities are developed over time and in response to the existing opportunities for expanding the scope of product use. However, new features and functionalities introduce two limits to the utility of product. First, in expectation the newer use cases are less impressive than the earlier ones, either applying to a smaller population or offering less additional value for users. Thus, growth in scope limits opportunities for further growth and firms respond by adjusting their R&D effort. The second consideration in assessing the utility is the introduction of various side effects and glitches along with the new features and functionalities. Those problems may not be fully found in the product development and testing process. For example, in case of medical technologies in-vivo tests are limited and rare side effects are usually not observed until the product has been in use by a large population. Therefore, new features often come with an increase in quality issues, which would, with a delay, be discovered and fixed.

The process to perceive the utility of the product requires users to test and work with the product, notice side effects, and write product reviews. It also may depend on the scientific community conducting research and publishing follow up studies. Typically, if people don’t know about a problem, that does not reduce their utility; nor do they worry about problems that are (known to be) fixed; so problems that are both recognized and not fixed hurt the perception of utility most. It takes some time to fix the problems

once they are found, as the company invests in corrective actions.

Based on the description above put together a simple model of the dynamics of product adoption in light of endogenous scope and utility. You can use the pacemaker case to ground your work in a tangible example, but aim for a model that is robust as a generic structure that can be applied to different cases with appropriate parameter values. Do not worry about competitive dynamics among different companies (e.g. you can think of it as a monopolist market). Work on building a model that is as simple as possible with robust equations that could generalize to different products going through these dynamics.

Submission Instructions

Put your Vensim model(s) in the shared dropbox folder under session 8. Please name your model submissions as: S08-<Last Name>-EndogenousDiffusion.mdl
for example, “S08-Rahmandad- EndogenousDiffusion.mdl”.

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