



15.879 Advanced System Dynamics Modeling

Spring 2025

Exercise 7- Market Growth with Boom and Bust

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

In this exercise we expand into modeling organizational dynamics spanning multiple sectors, where production, sales, and delivery interact. This assignment is motivated by the classical ‘Market Growth’ model by Jay Forrester, but please do not consult that model or its variants for building yours, try to come up with your own structures and formulations from scratch.

Consider a manufacturing firm in a large (but not unlimited) market which builds and sells a complex product to customers. For example, you can consider ASML that builds and sells photolithographic machines for electronic chip production facilities. However, you don’t need to base your model on ASML’s market or other details; the following should provide you with the structural features you need in your model. You are focused on capturing the interactions among sales, manufacturing, and product delivery, to understand the puzzling oscillations they have experienced in their sales despite an overall robust demand. Specifically:

- The product has a total market size, in potentially interested customers. For now, let us assume the firm has a dominant position in the market so you do not need to worry about modeling competition. The product is durable, with a life of a few years, so customers may only become interested in repurchasing the product after their previous version has depreciated. You are modeling the firm’s experience from the inception of the market where few customers already owned the product.
- The complex and expensive product is not sold through word of mouth or social media advertising. Instead, the firm uses a direct sales force to sell the product. The firm allocates a fraction of its total revenue to its salesforce. Each salesperson has a maximum productivity, in the number of potential customers they can approach and pitch to. Naturally their productivity will be limited by availability of interested customers.
- Conversion rate for customers, i.e. what fraction decide to purchase after being pitched to, would have a maximum and also depends on the firm’s reputation, in the market, at the time in terms of the delivery delay in providing the customer with their purchased units. The conversion rate declines when the firm exceeds customers’ desired delivery delay.
- Given the complex and expensive product, the firm operates a manufacturing operation with a backlog, rather than holding inventory. Basically, customer orders come to the backlog, and the firm fulfills those based on its production capacity with the aim of matching desired delivery delay of customers when feasible.
- If production capacity is lagging demand, delivery from backlog may go below orders and extend delivery delay. Those extensions are the primary signal to the firm for expanding their production capacity, by building new production facilities. Capacity building is slow (takes 2-3 years) and expensive, so the firm typically seeks strong

demand (i.e. delivery delay) signals to commit to expanding capacity. Once a manufacturing facility is built, it remains operational for two decades, though utilization may be below one if demand is not there.

Build a model of the mechanisms discussed above with a focus on understanding the historical trend (growth combined with periods of declining sales), projecting what may happen to the firm in the coming years, and offering operational recommendations to solve today's problems and maximize their future profits. You have flexibility in introducing required parameters such as price, wages for sales-people, desired delivery delay, and others. Include a simple accounting sector as well to track costs and revenues and enable cost benefit analysis. Given the limited time, strive for simplest model that captures the relevant mechanisms and is robust in extreme condition tests.

Bonus: If you have a chance, try formulating the fraction of revenue allocated to salesforce (a constant in your initial model) to be dynamic, so that it adjusts to the value marginal sales-people produce.

Submission Instructions

Put your Vensim model(s) in the shared dropbox folder under session 7. Please name your model submissions as: S07-<Last Name>-MarketGrowth.mdl
for example, "S07-Rahmandad- MarketGrowth.mdl".

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