How ChatGPT Writes a Complete Vensim Model

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Abstract

The process of creating a simulation model, particularly in System Dynamics, is a complex and time-intensive task. It begins with a clear understanding of the problem, followed by the identification of key variables, and culminates in the construction of a Stock and Flow Diagram (SFD) [1]. Traditionally, this process has been laborious, requiring significant manual effort to translate a conceptual understanding into a functional model. However, with the advent of advanced AI tools like ChatGPT, this process can be significantly streamlined. This paper explores how ChatGPT, in conjunction with the DAVID© (Draw A Vensim Initial Draft) tool, can automate the creation of a complete Vensim model, from problem description to a fully functional simulation.

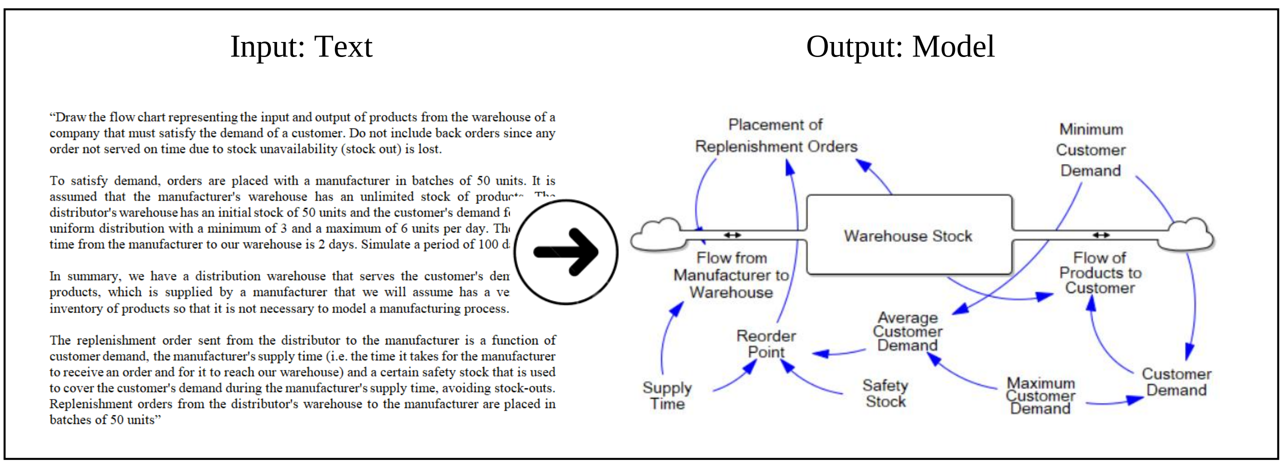


Fig. 1. From text to model

1. The Traditional Modeling Process

The journey of building a simulation model typically starts with a detailed description of the problem, including the key variables, relationships, and assumptions. This is followed by the creation of a Causal Loop Diagram (CLD) to visualize the feedback loops within the system. The next step, converting the CLD into a Stock and Flow Diagram (SFD), is often the most tedious part of the process. It involves defining stocks, flows, auxiliary variables, and their interrelationships, which can be both time-consuming and error-prone [2].

Once the SFD is constructed, the modeler must write the equations that govern the relationships between the variables. This step requires a deep understanding of the system and the ability to translate conceptual relationships into mathematical formulas. Finally, the model is implemented in a simulation tool like Vensim, where it can be tested, refined, and used for analysis [4].

2. The Role of ChatGPT in Model Creation and Education

ChatGPT, particularly versions 4.5 and o1, has emerged as a powerful tool to assist in the model creation process. It can help identify the elements of the SFD, classify variables, and even generate the majority of the model's equations. By leveraging ChatGPT, modelers can significantly reduce the manual effort required in the initial stages of model construction, allowing them to focus on refining and analyzing the system [3].

In the educational field, System Dynamics instructors need to change their teaching programs because students are undoubtedly already using AI. If students enter a prompt into ChatGPT and get a ready-made model, they will need training to analyze and validate the model, not so much to build it. This means instructors must force students to ask themselves: "Does this make sense? What happens if we adjust this variable? What is the real-world evidence?"

Part of the instructor's job now is to teach students to audit the AI's work and question whether the model reflects reality. This involves testing, adjusting parameters, and checking whether the simulation behaves as it should. Student assessment cannot be based solely on a student-created model; students must be able to present it clearly, explain its uses and limitations, and analyze possible policies based on the model [7].

Teachers will be required to make additional efforts to keep up with the continuing advances in AI, design more challenging tasks, and perhaps even learn alongside students.

3. Key Contributions of ChatGPT

1. Variable Identification and Classification: ChatGPT can analyze a textual description of the problem and extract the relevant variables, classifying them into stocks, flows, and auxiliary variables.
2. Equation Generation: Once the variables are identified, ChatGPT can generate the equations that define the relationships between them. These equations can be directly translated into Vensim's modeling language.
3. Guidance and Refinement: ChatGPT can provide step-by-step guidance on how to construct the SFD and refine the model, ensuring that the final product is both accurate and functional [6].

4. DAVID© (Draw A Vensim Initial Draft): Automating Vensim Model Creation

While ChatGPT significantly reduces the effort required to create a Vensim model, the process can be further automated using DAVID© [5]. This is a cutting-edge tool that integrates with ChatGPT to transform a textual description of a problem into a fully functional Vensim model. It automates the entire process, from variable identification to equation generation, and finally, the creation of an executable Vensim file.

5. How DAVID© Works

DAVID© operates in a series of well-defined steps, each designed to automate a specific part of the model creation process:

1. Define Variables: DAVID© begins by summarizing the problem description and extracting the relevant variables. It classifies these variables into stocks, flows, and auxiliary variables, creating the foundation for the System Dynamics diagram.
2. Write the Equations: Using the variables identified in the first step, DAVID© generates the equations that govern their relationships. These equations are then converted into the Vensim model format.
3. Draw the Stock and Flow Diagram: DAVID© writes a diagram based on the number of stocks and their interconnections, assigning the identified variables to the appropriate stocks and flows.
4. Add Auxiliaries and Arrows: DAVID© adds auxiliary variables and arrows to the diagram, ensuring that they are placed logically and without overlap.
5. Create the MDL File: Finally, DAVID© compiles all the information into a text file with an `.mdl` extension, which is the standard format for Vensim models. This file can be opened in Vensim for further refinement and simulation.

6. Detailed Steps to Use DAVID©

To use DAVID©, the user must follow these steps:

1. Write a Detailed Problem Description: Provide a clear and concise description of the problem, including all relevant variables, assumptions, and parameters. The description should be comprehensive enough to capture the essence of the system being modeled but concise enough to avoid unnecessary complexity.
2. Input the Text into DAVID©: Paste the problem description into the DAVID.docx file, which contains a predefined ChatGPT prompt divided into 10 steps. This file serves as the interface between the user and the DAVID© tool.
3. Execute the Prompt: Run the prompt DAVID© in ChatGPT (version o1 or higher). For versions 4o or DeepSeek, it is recommended to execute the steps one by one. This ensures that each part of the model creation process is handled accurately.
4. Generate the MDL File: Copy the output generated by ChatGPT and save it as a text file with an `.mdl` extension. This file contains the complete Vensim model, including all variables, equations, and diagram elements.

5. Open and Refine the Model in Vensim: Open the `.mdl` file in Vensim, make any necessary adjustments, and run the simulation. This step allows the modeler to refine the model based on their expertise and the specific requirements of the problem.

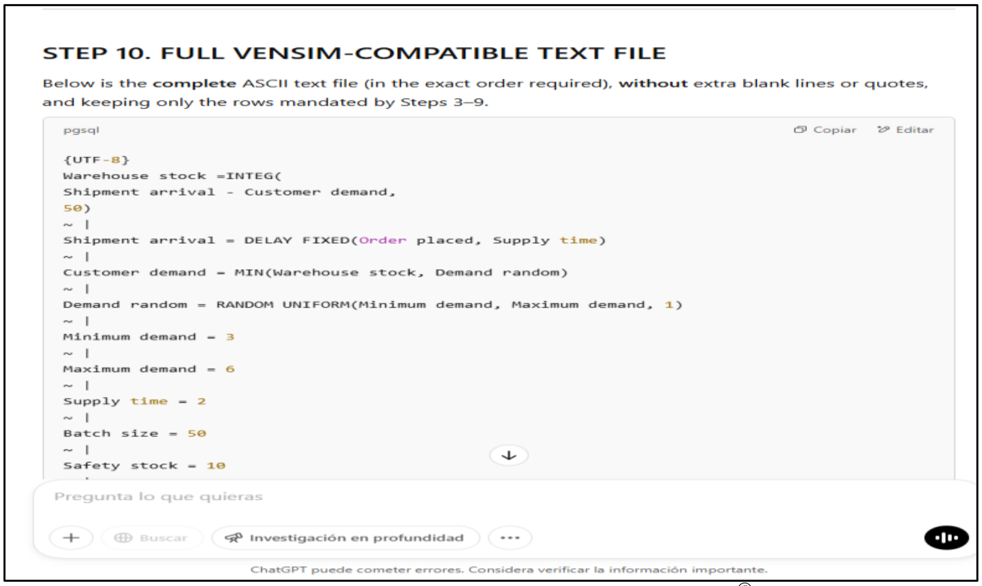


Fig. 2. Vensim code created by DAVID©

6. Case Study: Applying ChatGPT and DAVID© to a Real-World Problem

To illustrate the effectiveness of ChatGPT and DAVID©, consider a real-world problem: modeling the spread of a contagious disease within a population. The goal is to create a Vensim model that simulates the dynamics of disease transmission, recovery, and immunity.

Step 1: Problem Description

The problem description includes the following key elements:

- Variables: Susceptible population (S), Infected population (I), Recovered population (R), Transmission rate (β), Recovery rate (γ).
- Assumptions: The population is closed (no births or deaths), and immunity is permanent after recovery.
- Parameters: Initial values for S, I, and R; values for β and γ.

Step 2: Input the Text into DAVID©

The problem description is pasted into the DAVID.docx file, and the ChatGPT prompt is executed. DAVID© processes the text, identifies the variables, and classifies them into stocks (S, I, R), flows (transmission, recovery), and auxiliary variables (β, γ).

Step 3: Generate the MDL File

DAVID© generates the equations for the model, such as:

$dS/dt = -\beta \; S \; I \qquad dI/dt = \beta \; S \; I - \gamma \; I \qquad dR/dt = \gamma \; I$

These equations are compiled into an .mdl file, which also includes the SFD.

Step 4: Refine and Simulate the Model

The .md` file is opened in Vensim, where the modeler can refine the diagram, adjust parameters, and run the simulation. The results provide insights into the dynamics of disease spread and the impact of different intervention strategies.

7. Some models created by DAVID

Below are some examples of problems analyzed with DAVID©. The text entered in ChatGPT o1 and the diagram obtained are indicated. Since DAVID© creates an executable model, the graphical evolution of a system variable is also shown. These and other models have been used to design, calibrate and improve the results of DAVID©. In any case, it must be taken into account that DAVID© aims to offer a first draft of the model, which must always be validated by the user.

Example 1. Warehouse Stock

Resume: “Draw the flow chart representing the input and output of products from the warehouse of a company that must satisfy the demand of a customer. Do not include back orders since any order not served on time due to stock unavailability (stock out) is lost. To satisfy demand, orders are placed with a manufacturer in batches of 50 units. It is assumed that the manufacturer's warehouse has an unlimited stock of products. The distributor's warehouse has an initial stock of 50 units and the customer's demand follows a uniform distribution with a minimum of 3 and a maximum of 6 units per day. The supply time from the manufacturer to our warehouse is 2 days. Simulate a period of 100 days. In summary, we have a distribution warehouse that serves the customer's demand for products, which is supplied by a manufacturer that we will assume has a very large inventory of products so that it is not necessary to model a manufacturing process. Replenishment orders from the distributor's warehouse to the manufacturer are placed in batches of 50 units.”

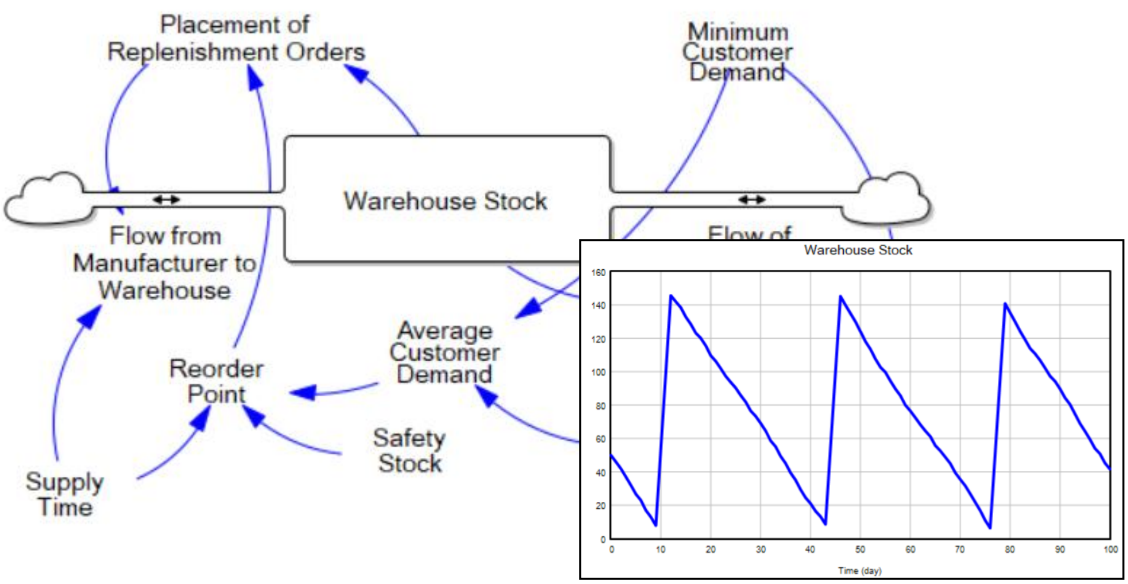
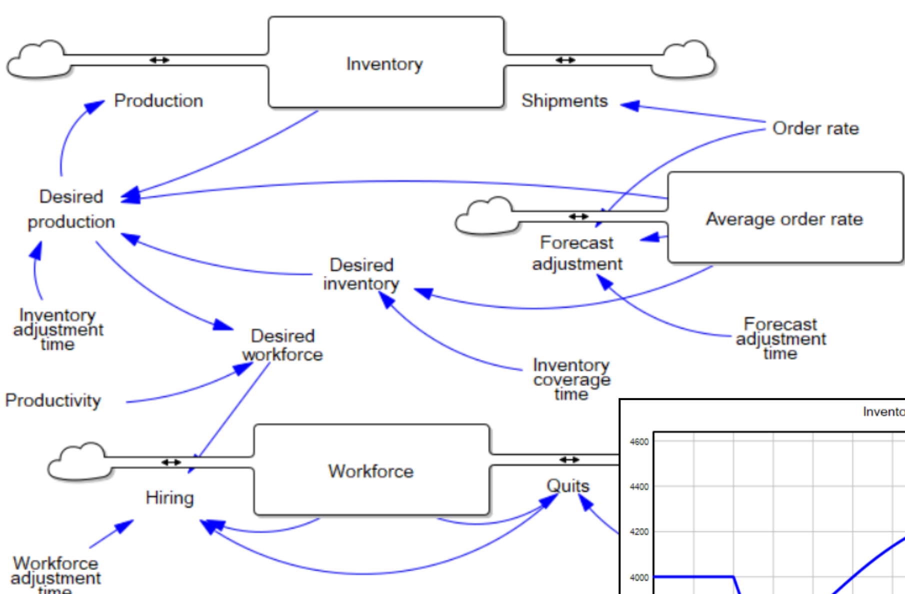


Fig. 3. Warehouse Stock

Example 2. Inventory Management

Resume: “A manufacturing firm has experienced chronic instability in its inventory stock and production rate. Discussions with management and workers on the factory floor have revealed the following information: 1. A firm supplies its customers from a stock of finished inventory, which is generally sufficient to meet orders as they are received. 2. Desired production is determined by anticipated (forecasted) shipments, modified by a correction to maintain inventory at the desired stock. 3. The firm forecasts shipments by averaging past orders over an eight-week period as a way of smoothing out any noise or lumpiness in demand. 4. The firm tries to correct discrepancies between desired and actual inventory in eight weeks. 5. Desired inventory is four weeks’ worth of anticipated shipments.

The firm’s actual production rate is assumed to equal desired production. The initial value for inventory is assumed to be equal to desired inventory, and the initial value of the average order rate is assumed to be equal to the shipment rate. As a result, the model will begin in an initial equilibrium regardless of the initial customer order rate. In this model customer orders will equal a constant of 1,000 units/week until the period 10, when orders step up by 10%, and then remain at the higher rate. Further discussions reveal that while the firm has ample physical plant and equipment, labour cannot be hired and trained instantaneously. In fact, it takes approximately 24 weeks to advertise for, hire, and train new workers. The firm has a no-layoff policy, and workers stay with the firm an average of 50 weeks (one year). The firm’s hiring policy is to replace those workers who quit, modified by a correction to bring the actual workforce into balance with the desired workforce. Because workers must give two weeks' notice, there is no significant delay between quits and replacement hiring. Because of the delays in hiring new people, it takes 24 weeks to make corrections to the workforce.”



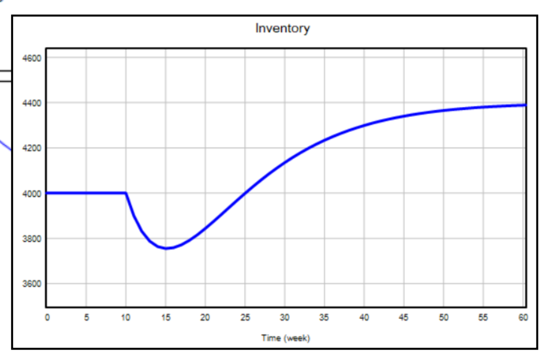


Fig. 4. Inventory Management

Example 3. Fishery

Resume: "The shrimp fishery is the third most important fishery on the coast of the Gulf of Mexico. In the Seventies, more than 20,000 tons per annum were caught but the catch diminished constantly and is presently 4,000 tons per annum. The shrimp population is concentrated now in fewer places and is more vulnerable to the fleet. We want to build a simulation model of the fishery of shrimp, focusing on the interaction between the shrimp population, the fishing fleet, and the economic dynamics of the fishery. We want a model to simulate the period 1950-2000.

1. Shrimp Population Dynamics. The shrimp population grows over time, but its growth is limited by the environment's carrying capacity (the maximum population the environment can support).

- The shrimp population grows at a rate of 50% per year. This is the natural growth rate of the shrimp biomass.
- The actual increase in the shrimp population depends on the current population and how close it is to the highest possible population (37,500 tons). If the population is close to the maximum, growth slows down because of limited resources.
- The shrimp population changes over time based on the population increase minus the amount of shrimp harvested by the fleet.

2. Fishing Fleet and Catch. The fishing fleet harvests shrimp, and the amount of shrimp caught depends on the fleet's size, efficiency, and the shrimp population.

- The amount of shrimp harvested per year depends on the catch capacity, how much the fleet can catch in a year, and the shrimp population relative to the highest population. If the shrimp population is small, the catch is reduced because there are fewer shrimp to catch.
- The catch capacity depends on the fleet size (number of boats) and the boat efficiency (how much shrimp each boat can catch per year).
- Boat efficiency increases over time due to technological improvements. It starts at 60 tons/boat/year and increases 5% every year until 2050."

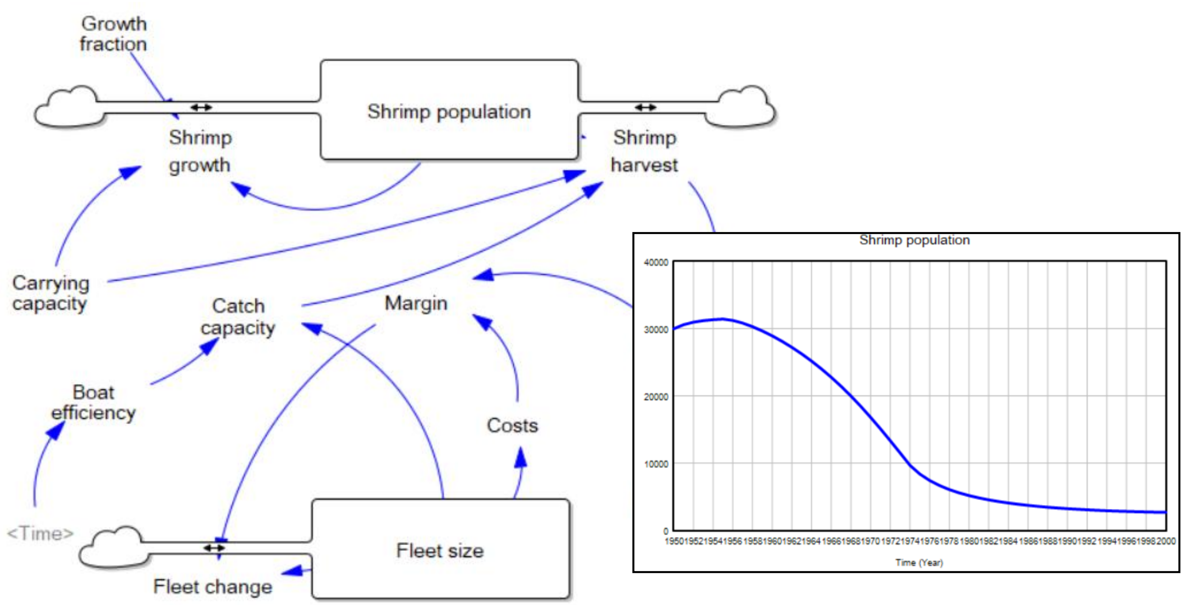


Fig. 5. Fishery

Example 4. Two reservoirs

Resume:"A hydroelectric power station located in the north of Spain has an upper reservoir whose discharge moves the electricity-generating turbines, and a lower one that acts as a reservoir, sending water back to the upper one to generate electricity again. Both reservoirs must regulate their water levels both for operational reasons and for reasons of public use, so they try to stay within a minimum and a maximum level. For this reason, discharges and returns are regulated based on these levels.

We want a model to simulate the interaction between the upper reservoir, which is fed by a river upstream, and which drains into the lower reservoir, thus driving the turbines of a Power Plant. The lower reservoir accumulates the water that has passed through the turbines, and discharges it into a river or returns it according to the requirements of the Power Plant. Both need to maintain a level control for technical reasons. This situation is modeled by three rates that regulate the interactions between reservoirs: charge rate, discharge rate and return rate.

Are defined the following rules:

Rule 01: Water flow from the Upper Reservoir to the Lower Reservoir. This rule calculates how much water flows from the Upper Reservoir (UR) to the Lower Reservoir (LR). The flow depends on the charge rate (how fast water is allowed to flow) and the current amount of water in the Upper Reservoir (UR).

Rule 02: Water flow from the Lower Reservoir back to the Upper Reservoir. This rule calculates how much water flows back from the Lower Reservoir (LR) to the Upper Reservoir (UR). The flow depends on the return rate (how fast water is allowed to return) and the current amount of water in the Lower Reservoir (LR).

Rule 03: Charge Rate. This rule determines the charge rate, which controls how fast water flows from the Upper Reservoir (UR) to the Lower Reservoir (LR).

The charge rate depends on the water level in the Upper Reservoir (UR). It checks if the water level is:

- Too low: If the water level is below a minimum height (`height min UR`), the charge rate is set to 0.005 (very slow flow).
- Too high: If the water level is above a maximum height (`height max UR`), the charge rate is set to 0.02 (faster flow).
- Normal: If the water level is between the minimum and maximum, the charge rate is set to 0.01 (moderate flow).

Rule 04: Discharge Rate. This rule determines the discharge rate, which controls how fast water is released downstream from the Lower Reservoir (LR). The discharge rate depends on the water level in the Lower Reservoir (LR). It checks if the water level is:

- Too low: If the water level is below a minimum height (`height min LR`), the discharge rate is set to 0.005 (very slow flow).
- Too high: If the water level is above a maximum height (`height max LR`), the discharge rate is set to 0.02 (faster flow).
- Normal: If the water level is between the minimum and maximum, the discharge rate is set to 0.01 (moderate flow).

Rule 05: Discharge Downstream. This rule calculates how much water is released downstream from the Lower Reservoir (LR). The flow depends on the discharge rate and the current amount of water in the Lower Reservoir (LR)."

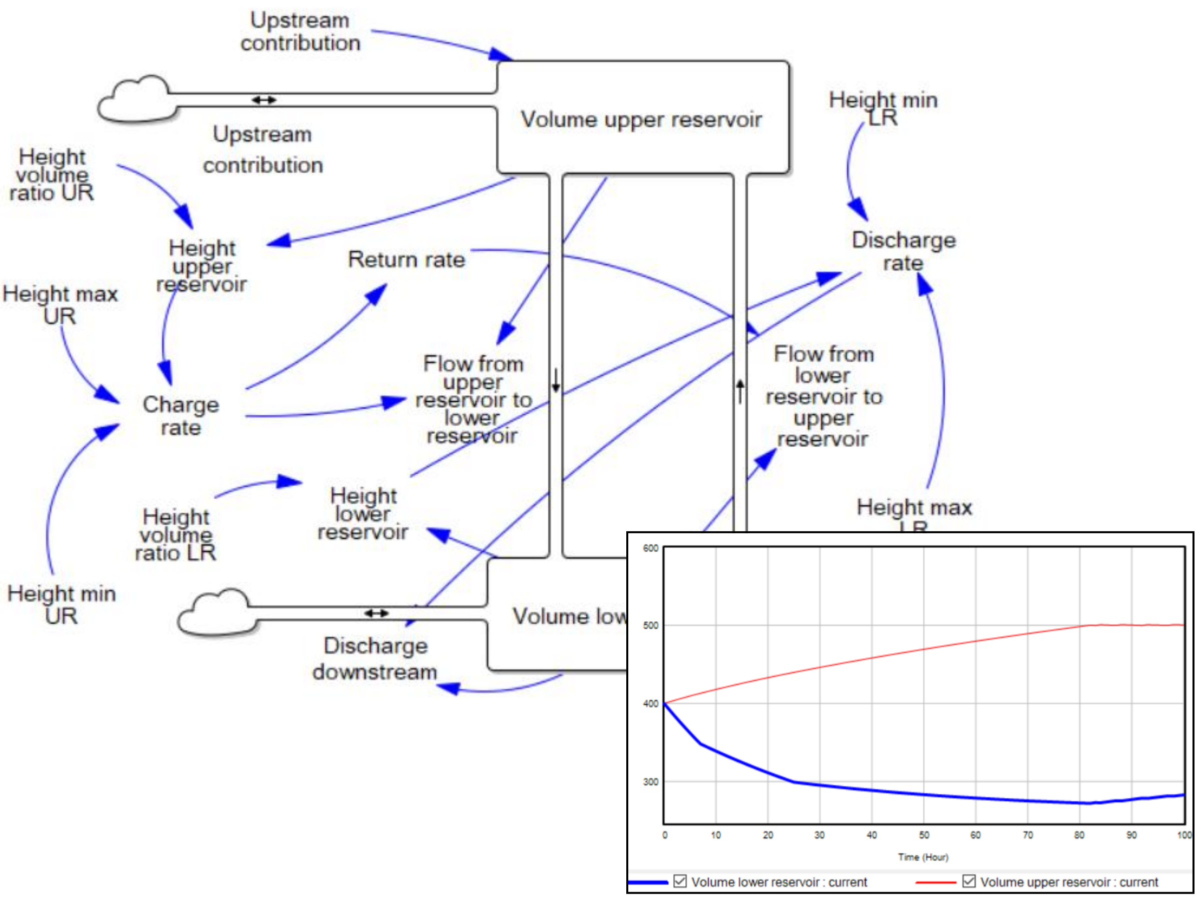


Fig. 6. Two reservoirs

Example 5. Cows and jaguars

Resume: "The aim is to simulate the impact of population control policies on jaguars (Panthera onca) and the total sales of the cattle of cows and calves farm in Paraguay. Jaguars are disappearing in areas where humans exert pressure, eliminating their usual prey or hunting the jaguars in the area. Their diet is quite adaptive, since it varies depending on the availability of prey. Where there is abundant prey, their diet is more selective; and where prey is scarce, their diet is more opportunistic.

We will simulate from 2020 to 2035, to see the impact of some policies in the medium term. The estimated number of jaguars on the farm is based on observations by property workers who walk through the productive area daily. This estimate depends on the number of births, natural deaths and unnatural deaths that occur throughout the year.

The number of cows and also calves death by predation, depends of the parameter cattle attacked by jaguar and also the number of jaguars. The deaths of jaguars by hunting every year depends from cattle attacked by jaguars, the parameter jaguars hunted for every cow killed and the ratio Jaguars by initial jaguars."

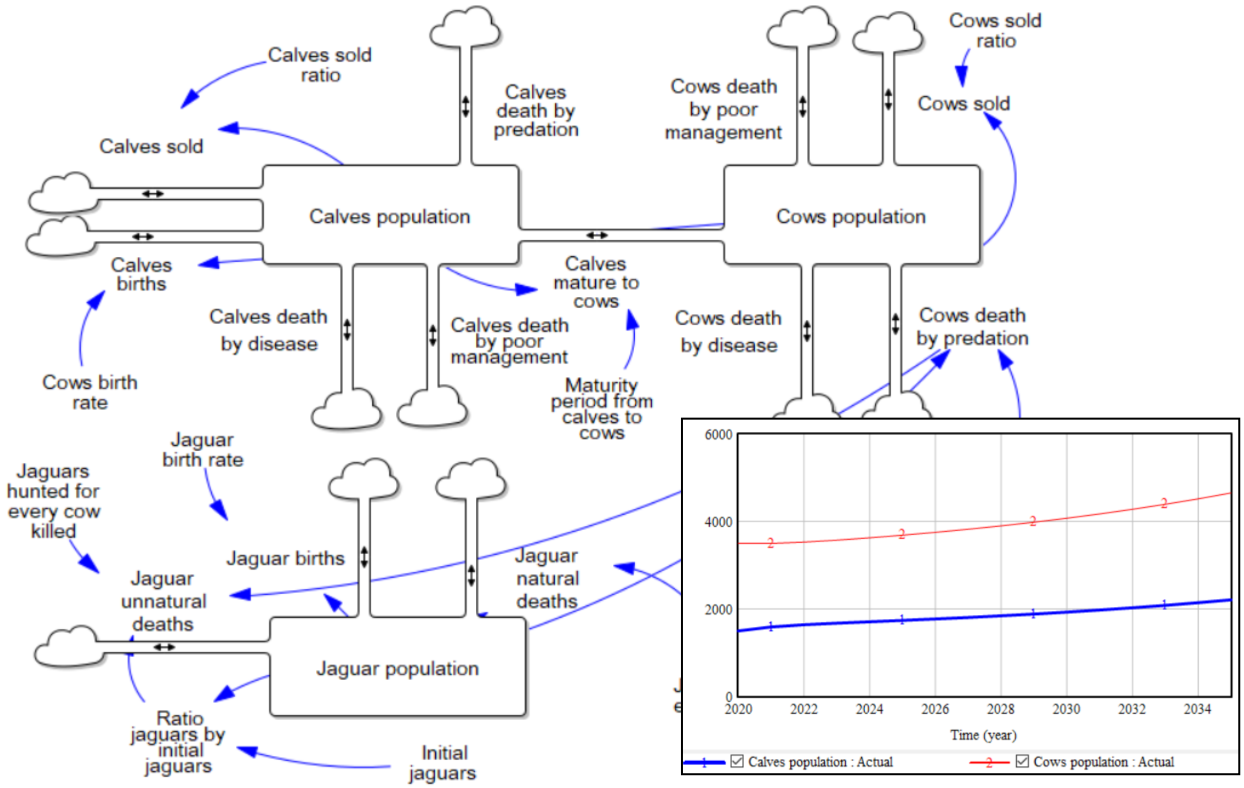


Fig. 7. Cows and jaguars

8. Validation

Now we take the "Example 2. Inventory Management" analyzed with DAVID©. This and other models have been used to design, calibrate and improve the results of DAVID©. It should be noted that DAVID© is intended to offer a first draft of the model. User must always validate the generated model.

To validate DAVID©, we employ the "Tests of Model Behavior" [8], comparing the output of a model generated by DAVID© with that of a reference model addressing a similar problem in the book "Business Dynamics" by Sterman [2] in chapter 18 "The manufacturing supply chain". This validation method verifies a model's accuracy by assessing whether its behavior aligns with either the real-world system or, in our case, an established and recognized reference model.

Figure 4 shows partially the Vensim code created by the tool. The code must be copied and pasted in a *.txt file that must be later renamed to a *.mdl file extension. Figure 2 shows the Stock and Flow diagram created by DAVID© in Vensim code.

Figure 8 displays the results of the simplified Manufacturing Supply Chain model developed in DAVID©, adapted from John Sterman's original work in Business Dynamics [2]. This model analyzes how sudden changes in customer orders affect a manufacturing company's operations.

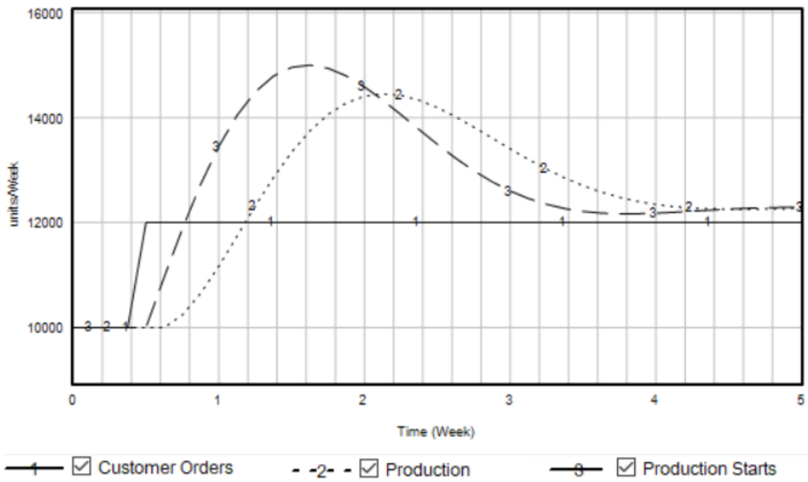


Fig. 8. Results of the model created by DAVID©

Figure 9 presents the behavior of Sterman's [2] Manufacturing Supply Chain model, illustrating fluctuations in both customer orders and production. The patterns observed closely align with those generated by the simplified DAVID© version, demonstrating the consistency between the two models.

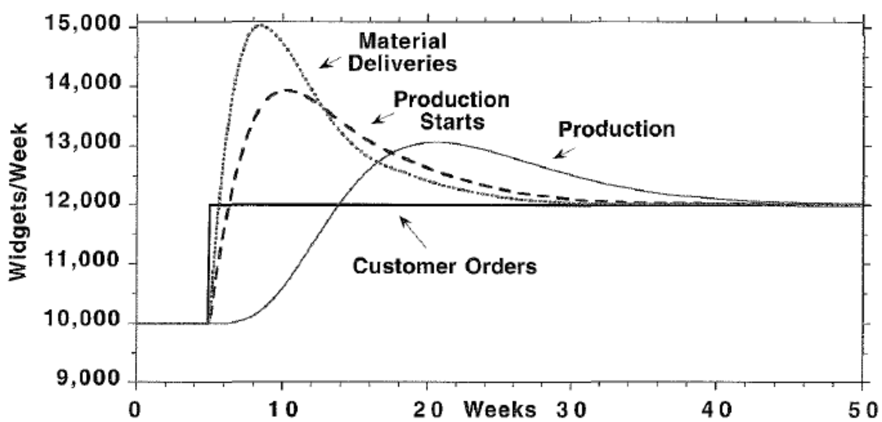


Fig. 9. Manufacturing Supply Chain model. Source Sterman[2]

9. Limitations of DAVID©

DAVID© is an algorithm based on ChatGPT, which introduces certain constraints for users. Key limitations include:

1. Compatibility Restrictions: The algorithm is validated and optimized for ChatGPT o1 and 4.5, which are paid options. Results with other AI brands (DeepSeek, Gemini, etc.) or free versions of ChatGPT are not as good.

2. Complexity: It is not recommended for models with more than 8 Stocks, as ChatGPT currently struggles to deliver reliable results with more complex queries.
3. High Sensitivity to Initial Input: The algorithm uses strictly to the provided text and does not introduce unmentioned variables, making the output highly dependent on the initial input.
4. Non-Reproducible Results: Unlike deterministic mathematical algorithms—where the same input always yields the same output—DAVID© may produce varying (though similar) results for identical queries due to the inherent nature of AI-generated responses.

10. Advantages of Using ChatGPT and DAVID©

The combination of ChatGPT and DAVID© offers several advantages for modelers:

1. Time Efficiency: By automating the initial stages of model creation, ChatGPT and DAVID© significantly reduce the time required to build a Vensim model. This allows modelers to focus on the more critical aspects of analysis and refinement.
2. Accuracy: The automated process minimizes the risk of human error, ensuring that the model is both accurate and functional. This is particularly important in complex systems where small errors can lead to significant deviations in the simulation results.
3. Ease of Use: Even novice modelers can use these tools to create complex models, as ChatGPT provides step-by-step guidance throughout the process. This lowers the barrier to entry for System Dynamics modeling and makes it accessible to a wider audience.
4. Flexibility: The tools can be adapted to a wide range of problems, making them suitable for various applications in System Dynamics. Whether modeling economic systems, ecological systems, or organizational behavior, ChatGPT and DAVID© provide a versatile solution.

Conclusion

The integration of ChatGPT and DAVID© represents a significant advancement in the field of System Dynamics modeling. By automating the creation of Vensim models, these tools allow modelers to focus on the analysis and refinement of their models, rather than the tedious task of initial setup. Whether you are a seasoned modeler or new to System Dynamics, ChatGPT and DAVID© offer a powerful and efficient way to create simulation models, transforming the way we approach complex problems.

As AI technology continues to evolve, tools like ChatGPT and DAVID© will likely become even more sophisticated, further reducing the barriers to entry for System Dynamics modeling and enabling more people to leverage the power of simulation in their work. The future of System Dynamics modeling is bright, with AI-driven tools paving the way for more efficient, accurate, and accessible modeling solutions.

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Videos

https://youtu.be/t1yKiHKLBE8 (English, short)
https://youtu.be/LpfdO6xovBo (English, long)
https://youtu.be/BLFK7TS4nFc (Spanish)

BOOKS

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