SYSTEMS DYNAMICS TECHNIQUES UTILIZATION IN BUSINESS STRATEGY MODELING

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Abstract. *Systems dynamics techniques constitute a rigorous approach of modeling that utilizes computer simulations to help one understand the structure and the dynamic of complex systems. The objective of the proposed theme is to evaluate the strategy of a company (shop network) to expand the number of clients and consequently increase profitability. For that purpose, it was carried out a broad bibliographic research in order to provide a solid theoretical foundation for the study. This work is based primarily on the studies of Jay Forrester (1960) and the educational material utilized in M.I.T. It was proposed a complex problem (shop network) that permitted the modeling, coding, gathering of historical data, validation of the model, simulation and analysis of results. Simulations were carried out using the VenSim tool. Four strategies were proposed to increase the number of clients of the company in question (and consequently profit). After simulating each strategy, a comparison between the strategies was made and it was verified that the more effective is the expansion by franchise. However since the company does not yet possess the logistic structure to cope with a growth of such magnitude, it is suggested that for the next few years the company should adopt the strategy named "National" while developing at the same time the necessary structure for future franchise operation.*

Keywords*: system, dynamic, strategy, simulation, evaluation, business.*

1. Introduction

Systems dynamics techniques constitute on the one hand a set of conceptual tools which may be used to better understand the structure and dynamics of complex systems. On the other hand constitute a rigorous approach of modeling that utilizes computer simulations to define more effective organization types and policies. Together, said tools may be used to create management simulators where space and time may be compressed and decelerated so as to allow the experimentation with long term side effects, organizational learning, as well as the design of high performance structures and strategies.

Nowadays systems dynamics techniques are being widely used in several specialized fields dealing with subjects such as: product design and development; government policies formulation; population growth studies; dynamics of disease dissemination; traffic problems; social issues; etc.

The objective of this paper is to show how several strategic options that presented themselves to a commercial company were evaluated, and decisions on future operations were taken using systems dynamics techniques. For that purpose, it was carried out a broad bibliographic research in order to provide a solid theoretical foundation for the study. The proposed model was based primarily on the works of Bellinger (2004), Coyle and Morecroft (1999), Forrester (1994), Kirkwood (1998), Martin (1997), Sterman (1998), Morecroft (1999) and MIT educational material (2003).

Initially the problem faced by the authors will be defined and some considerations on fundamentals will be made. Then the specific model used will be described and discussed. Based on simulation results, there will follow a discussion of the practical situation, bearing in mind that a typical modeling process is an iterative one in the sense that results from one step may lead to the revision of results obtained in previous steps.

2. Strategic Analysis

2.1 Problem definition

The problem under consideration refers to the dynamics of new clients – and resulting increase of income – in a network of commercial shops. Considering the fierce competition faced by the company in their respective commercial sector nowadays, it is realized that strategic mistakes and ineffective expenditures may have disastrous and even fatal consequences. Therefore, for the purpose of attaining the Management established goal of increasing the number of clients, several strategic options were carefully discussed and eventually four strategic lines have been proposed:

- **Local** – meaning high investment over a short period of time in order to open new establishments and increase market shares in cities already covered by the existing network.
- **National** – meaning progressive investments in order to expand the network to other cities and states.
- **Moderate** – meaning something in between present policies and local expansion. The main difference residing in the speed of the opening of new shops.
- **Franchise** – meaning a sharp departure from present policies.

Initially a simplified map was drawn up showing the main departments and how they interact. Then an analysis of market dynamics was carried out in order to identify those factors that could be monitored so as to simulate and define a market expansion strategy (increase in the number of clients). Following, it was considered how systems dynamics techniques could be used to evaluate said strategy and its success in increasing the company's accrued gain, since investments in advertising, marketing and expansion must be covered by an increase in income.

2.2. Formal model

In order to build a mental model and then develop a formal model it is necessary to relate the identified factors to systems dynamics concepts. In other words, it is necessary to consider a typical modeling problem where business structures are converted into systems dynamics concepts. In addition, cause and effect relationships within the system should be defined so as to aid in adequately formulating the problem. Once the problem has been formulated, some constants should be defined and then the proposed strategies can be simulated.

The formulation that has been used can be easily understood by examining the model shown in Fig. 1. Those arrows arriving at any one variable must necessarily be taken into consideration when writing the equation that describes the considered variable's behavior.

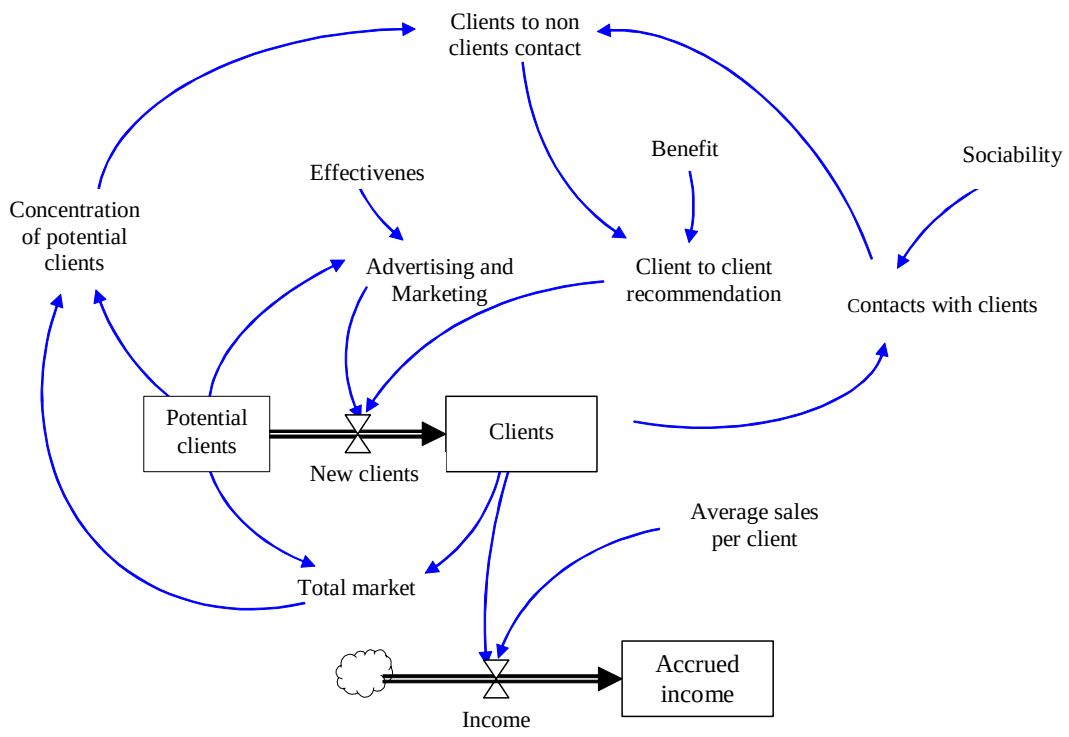

Figure 1. Model describing the system's dynamic behavior.

As can be seen in Fig.1, three factors have been considered as reservoirs: Clients; potential clients; and accrued income. Other items shown are either variables or system constants.

2.3. Model validation

Before simulating strategies for which there are no actual data available it is essential to validate the model. That is, to calculate constants and initial conditions using known historical data and then verifying whether results are close enough to real values. Therefore, validation was carried out for variables 'clients', 'average sales per client', 'income', and 'accrued income' by comparing values obtained using the simulation model with those known past values supplied by the organization's management.

Figure 2 shows an example of said validation. As can be readily seen results agree quite satisfactorily. It is important to remark that **absolute values herein shown are fictitious**. However, values shown for increase rates both in the number of clients and in average sales per client are real.

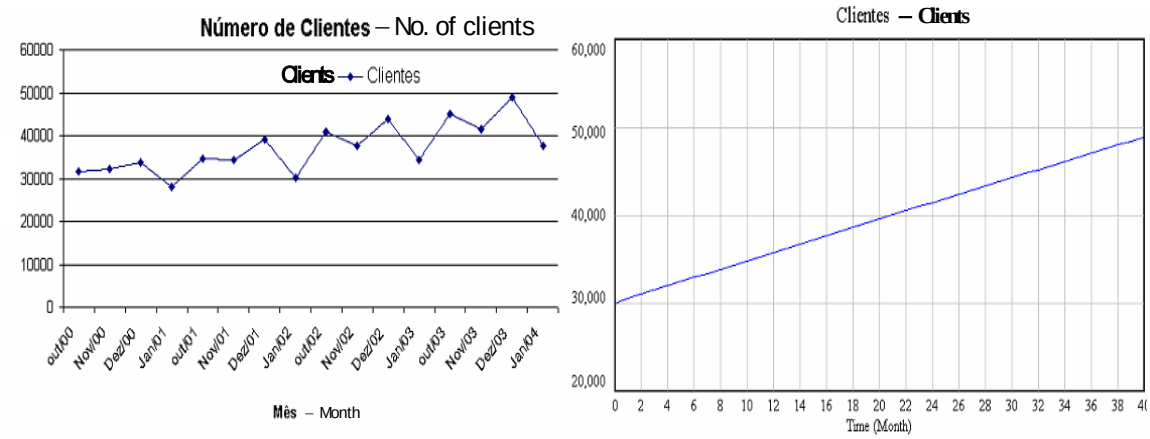

Figure 2. No. of clients historical data versus simulation results using model in Fig. 1.

Another important factor that should be considered is the seasonal nature of events. This implies that data relating, e. g., to the summer season may differ from those relating to the other seasons along the year. Therefore, a detailed study of the company's sales values and number of clients showed that it was better to work with data relating to a single season.

Observing historical data it can be verified that in October 2000 the company had 31.000 clients, whereas in December 2003 this number was close to 49.000 clients (both fictitious values adopted for presentation purposes only).

2.4. Simulation and analysis of results

Once having validated the proposed model, the authors used the VenSim tool to carry out a number of simulations the results of which are shown in Figs. 3 to 11. In order to avoid a certain redundancy, not all variables are represented in said figures, only those considered relevant to the effort of identifying differences between proposed strategic lines. However, this does not mean that other variables are not important, only that their graphs show similarities rather than differences. Considering the envisaged scenarios, a five year period was deemed adequate by management for the study of the present four strategic options.

Curves shown in Figure 3 for 'potential clients' were arrived at taking into consideration the actual geographic location of stores, in order to introduce local economic conditions and birth rates. Data for the cities included in the study were obtained from IBGE (2004). Curves in Figure 4 were based mainly on data obtained through the company's 'fidelity card' but also from other devices used for client follow-up. Figure 5 shows combined results deriving both from the organization's advertising and marketing initiatives and from spontaneous clients' recommendations, considering respectively adequate values of effectiveness.

When examining Figures 3, 4 and 5 one can see that both 'local' and 'moderate' options lead to market saturation along the considered five year period, while 'franchise' and 'national' options will provide an increase in clients' numbers over the same period.

On the other hand, although a steeper curve in Figure 3 shows a larger number of potential clients (non-clients) when the 'national' line is considered, Figure 4 reveals that the 'franchise' line is more effective as far as the evolution of clients is concerned, producing a result twice as large as that achieved with the 'national' option at the end of the five year period. Figure 5 confirms the advantage of the 'franchise' over the 'national' strategic line.

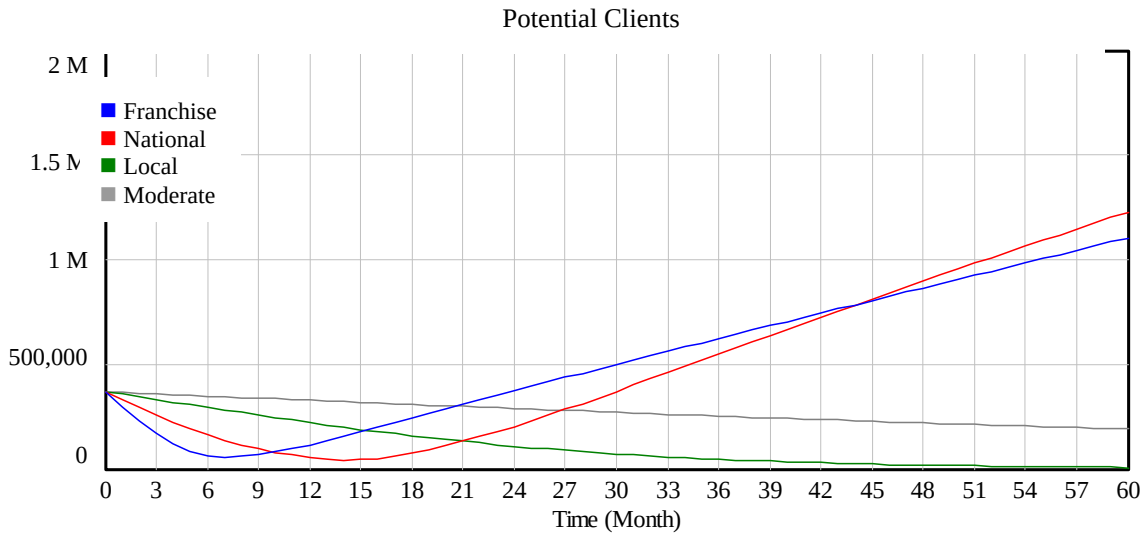

Figure 3. Potential clients.

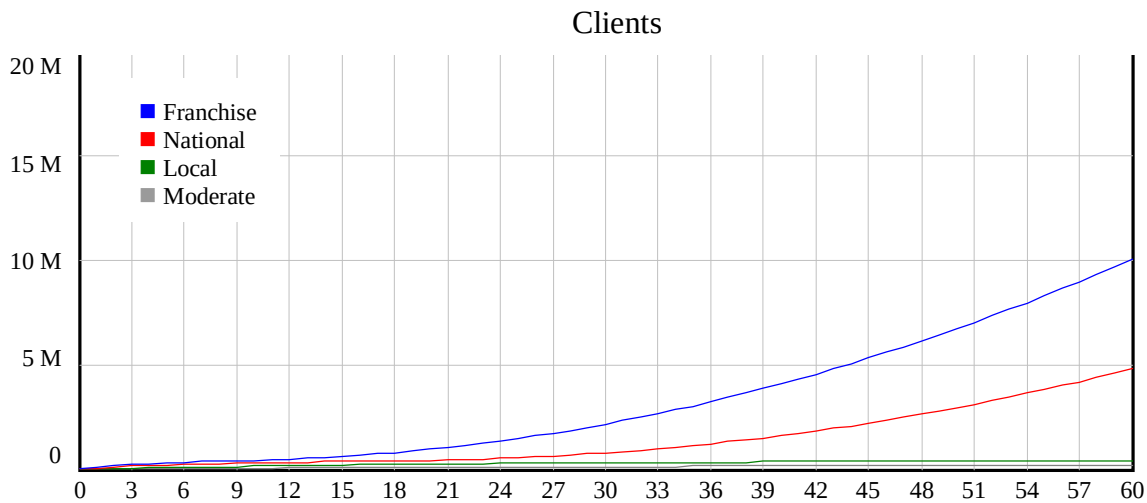

Figure 4. Clients.

As can be readily seen, there is a considerable difference in outcomes provided by one pair of options and the other. ‘Local’ and ‘moderate’ options meaning a rather conservative approach, and ‘franchise’ and ‘national’ options a more aggressive one. It was eventually realized that the former pair could not support the strategic goals of the organization’s management. As to the latter, it proved capable of enhancing the desired number of clients. Final decision, therefore, became a matter of the management’s disposition towards expansion through a ‘national’ or a ‘franchise’ strategic line.

Figure 5. New clients per month.

Figure 6 shows separately the effect of client to client recommendation that proved to be one of the most difficult effects to estimate. In order to adequately assess the effectiveness of spontaneous client to client recommendations, interviews were carried out with clients in several stores during the months of June and July 2004. Information gathered from such interviews made it possible to estimate some constants to be used in the simulation model.

Curves in Figure 7 were obtained considering the number of potential clients in relation to the whole market, in order to give the researchers an idea of concentration over the five year period of strategic projection, with a view to better analyzing and understanding the increase in clients' numbers due to the contributions shown in Figures 6 and 8.

It can be noted in Figure 6 that for 'local' and 'moderate' options this variable's contribution decreases rapidly as non-clients become clients, since the concentration of potential clients presented in Figure 7, as would be expected, also experiences fast decline. For the 'moderate' and more conservative option such decline is practically linear.

Figure 6. Contribution of client to client recommendation per month.

On the other hand, Figure 7 shows that the concentration of potential clients for more aggressive strategic lines such as 'national' and 'franchise', although experiencing some oscillations over the period tend to stabilize in the fifth tear.

Thus, aggressive strategies can significantly benefit from this type of spontaneous activity from clients over the five year period.

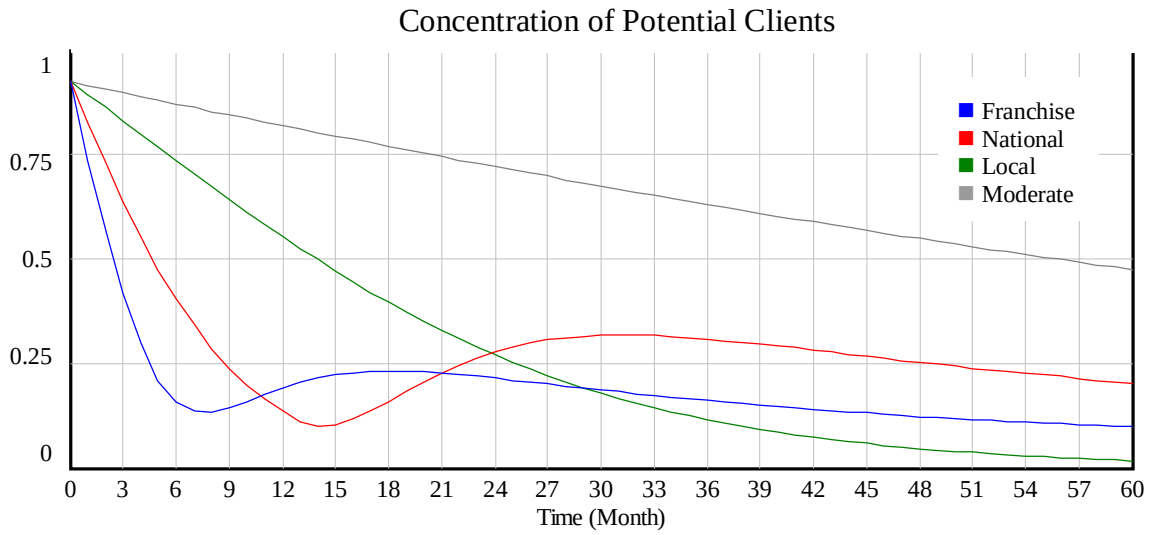

Figure 7. Concentration of potential clients

Curves in Figure 8, analogous to those in Figure 6, show separately the effect of advertising and marketing efforts. Necessary data, such as how and when advertising and marketing initiatives are carried out, were supplied by the organization's Marketing Department. By means of a cross-analysis between enhancement in clients' numbers and said initiatives over the same periods along the year, it was possible to adequately estimate the effectiveness and the contribution of advertising and marketing activities.

The examination of curves in Figure 8 provides also similar conclusions to the ones derived when examining curves in Figures 6 together with those in Figure 7.

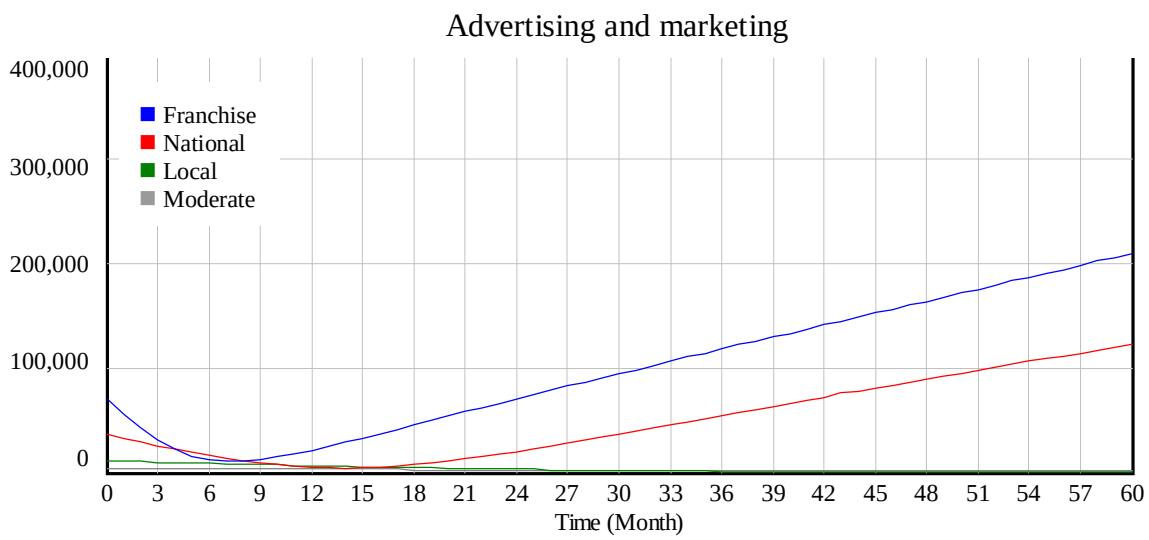

Figure 8. Contribution of advertising and marketing

Figures 9 and 10 reveal what should have already been expected from previous analyses. Considering the increase in clients' numbers allowed by 'national' and 'franchise' options, these two aggressive strategic lines are likely to provide

a much higher monetary return than the other two more conservative ones, both in terms of income - monthly and accrued alike – and of increase in average sales per client. Thus, Figure 11 clearly presents the fact that ambitious expansion will be restricted to the aggressive options.

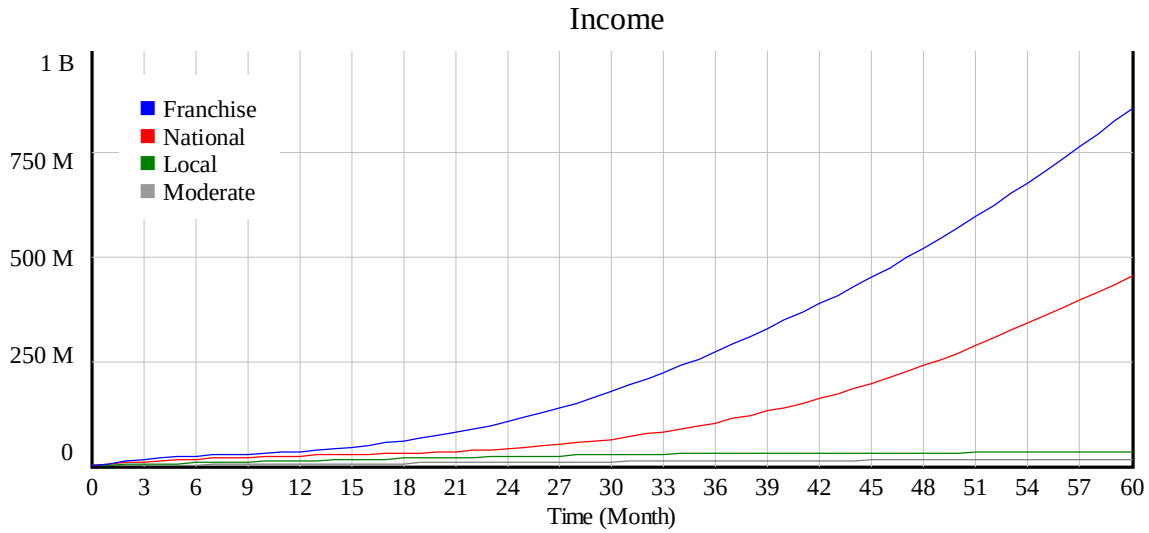

Figure 9. Increase of monthly income

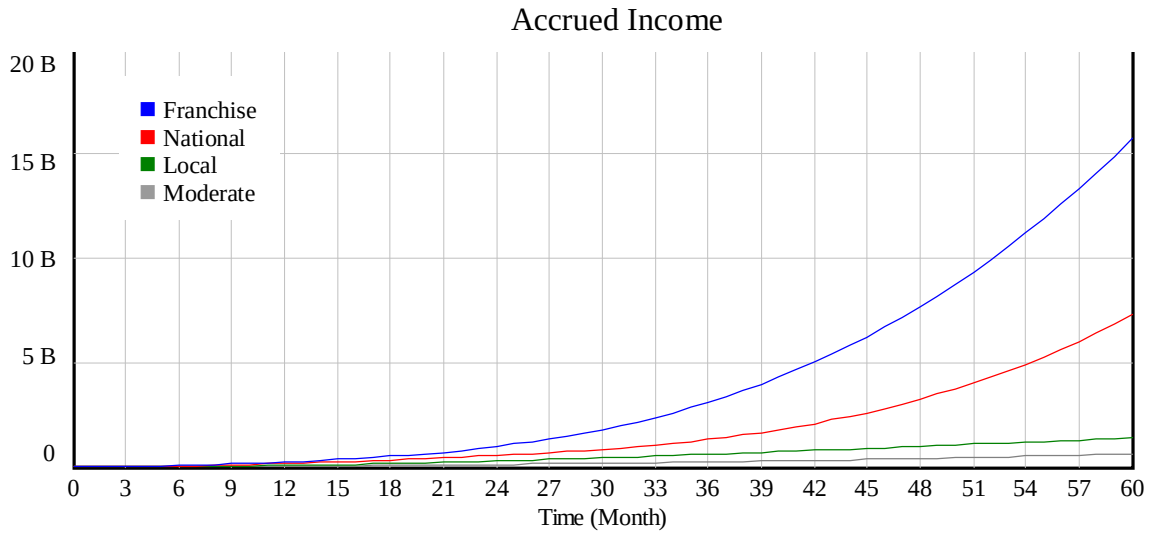

Figure 10. Accrued Income

Although previous simulations and considerations have revealed that the 'franchise' option possesses clear advantages over the 'national' line as far as increase of clients' numbers, income and sales per client are concerned, it may eventually result in increased logistic and legal costs. In addition, it should be also pointed out that the 'national' line may be more advantageous when considering such aspects as ease of control of operations and assurance of service quality to customers. Therefore, before reaching a final decision between options, it was decided to carry out a broader discussion taking into consideration all the relevant aspects of the business scenario.

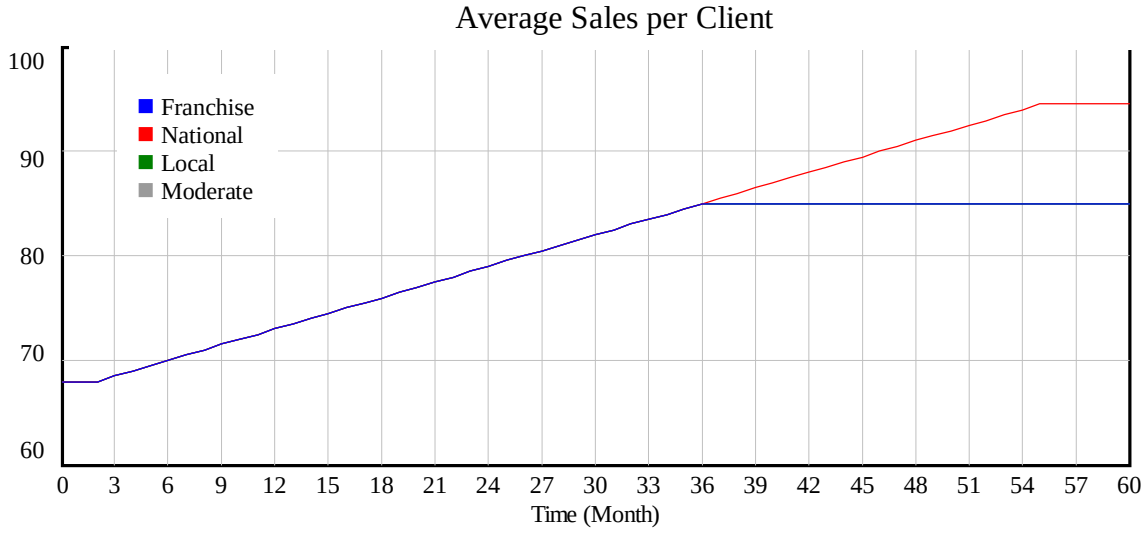

Figure 11. Average sales per client

3. Conclusion

Bearing in mind demographic data and near saturation conditions in the local market, a report supplied by the company's advertising consultants warned that it is becoming increasingly difficult to increase the effectiveness of advertising in regions already covered by the network. In addition, when defining objectives, Management established that they intended to increase the number of clients so as to become the leading specialized network in their trade sector. Thus, it can be said that both 'moderate' and 'local' strategic lines offer results that are not considered capable of leading to the expected goals. This fact reduces the discussion to the two remaining lines: 'national' and 'franchise'.

Considering both the simulations performed and the company's present structure, as well as the needs of other parties, it was decided not to adopt the 'franchise' line at the moment, in spite of its clear advantages in terms of increase of clients' numbers, income and sales per client. Nevertheless, it was considered that only some adjustments are necessary for the eventual adoption of this strategic line.

Therefore, the following suggestions were submitted to the company's Management:

1. Present adoption of the 'national' strategic line;
2. Cost analysis for the implementation of the 'franchise' option;
3. In-depth study of the franchise business and required competences.

4. Acknowledgements

This work owes very much to several members of the commercial organization under consideration. The authors are deeply grateful for their understanding and cooperation.

5. References

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