improve. Fifth, there is a tendency of recovery for the internal China market. Among these, increasing internal needs and consumption is the key to future economic development in China. To this end, two measures have to be taken: (1) increase personal earnings, and (2) create internal consumption opportunity (particulary in housing). From a more official source, GDP for 1999 is forecasted to be within the 7% to 8% level, according to an authority of the Beijing Government. This serves as a guideline rather than a goal, thus, leaves more room and flexibility in development. To achieve this, increasing internal consumption and needs as well as increasing investments will be the main pursuits.

To sum up, the overall investment environments of both SEZs are satisfactory and improving due to the continuous drive for growth at this difficult time. Each of them has their own advantages (as seen in Table 6 and 8) and they are still attracting investments. But, one thing is sure about their fate: they are and will face more severe competition from other regions in China. The difficulty will aggravate as heightened measures are being initiated by the Chinese Government to equalize the investment environment among different regions within China. And, the adverse effect of the Asian turmoil is still unsettled and uncertain. What should enterprises already operating in the SEZs do? In fact, there is no easy answer and more research will be needed to investigate the probable answer. However, one guiding philosophy is certain: enterprises should take advantage of the privileges they are enjoying to build long-term, sustainable and unique competitive advantages.

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Impact of sardine catches variations on the Portuguese processing fish industry. A system dynamics study*

The recent evolution of *sardina pilchardus* stocks along the Portuguese coast indicates a potential danger of exhaustion. As the Portuguese canned sardine industry is totally dependent on those catches, it was necessary to evaluate the impact it will undergo under the foreseeable restrictions.

An integrated system dynamics model of the supply and demand of sardine and of the production of canned sardine was developed and tested, and different scenarios were explored.

The design and tests of the supply and demand section of the model — taking into account the fresh fish market and the quantities for industrial use — were based on historical data. The system dynamics sub-model of industrial production assumes that sardine price is the major variable affecting the industry performance.

The simulation results provide information on how the different groups of companies will behave, and help put in perspective the social and economic effects that can be expected.

1. THE PORTUGUESE CANNED FISH INDUSTRY

Portuguese preserved and canned fish industry, after a century´s evolution, has hyper-specialised in sardine and tuna-fish species, with a sardine prevalence. During the last five years, it registered an annual production of 25 Kton of canned sardines, of which 55% to 70% have been exported for a small number of countries. This situation, together with the fact that usually the sales take place under the importer's brand name or under a brand name which it appoints, has driven the industry to a vulnerable position.

* This paper has been prepared on the basis of a presentation at the XIth Annual Conference of the European Association of Fisheries Economists, Dublin, 7th-10th, April, 1999.

On the supply side, it is important to notice that the processing fish industry in Portugal absorbs approx. 50% of the total sardine landed in Portuguese harbours. Since "sardine" name, in the European Union market, is legally restricted to the species *sardina pilchardus*, Walbaum, 1792, no other significant source is available. Sardine average prices at the wholesale fish market have steadily increased since 1986.

In Porter's terms (Porter, 1980), "industry falls between the devil — more and more demanding and powerful customers — and the deep blue sea — suppliers whose bargaining power is based upon EU regulations." (Dias, 1998). Additionally, the survival of Portuguese canned fish industry depends on the canned sardine production (Dias *et al.*, 1998a), since the reputation earned by the latter is critically dependable on the quality and abundance of fresh sardines and the excellence of workers' skills.

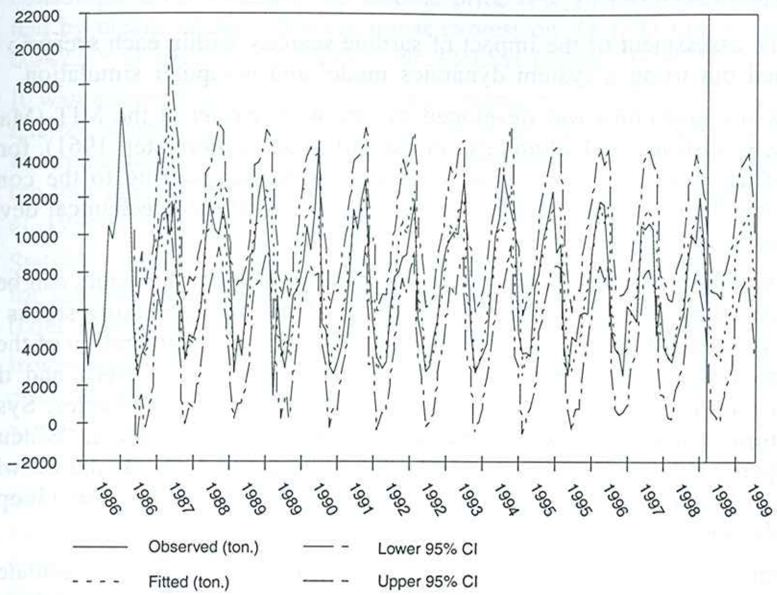
2. RECENT EVOLUTION OF SARDINE LANDINGS

Sardine (*sardina pilchardus*, Walbaum, 1792) has its natural environment in a large area of the Northeast Atlantic, the Mediterranean and the Black Seas. National catches, relying upon a sole fish bank, take place along the Portuguese coast and oscillate around an annual total of 80 Kton. Sardine is traditionally caught by purse-seine fleet vessels, belonging to Producers' Organisations (PO)[(1)]; the exploitation pattern has basically remained the same, in the recent years, as was confirmed by a Box-Jenkins analysis on the data concerning sardine landings in Portugal, since 1986 (Dias *et al.*, 1999a) — see Figure 1.

However, data collected during the IPIMAR[(2)] acoustic surveys, in 1995 and 1996, caused some concern, given the signs of reduction of the spawning biomass and of the total biomass. Alterations of the sardine distribution pattern were also detected, with a higher concentration by the coast.

A recovery plan which would involve the European Commission, Portugal and Spain was launched and, in this context, the Portuguese public authorities agreed with the PO on an "action plan for sardine fisheries" to be carried out between 1997 and 1999, which included among other measures, a limitation of the total catches, as described elsewhere (Dias *et al.*, 1999b). An assessment about the impacts of the alleged sardine scarcity on the canning industry was also requested from ISCTE, and a part of it is presented in this paper.

Figure 1: Pattern of sardine landings and SARIMA model $(0,0,1)(0,1,1)^{12}$ adjusted



Source: DGPA, Dias *et al.* (1999a).

After considering the whole set of available data about the situation, three alternative scenarios were set up for the evolution of landings, which, for this purpose, were assumed to coincide with the catches:

1. **The optimistic scenario**. It is a reference scenario corresponding to the 1997 actual situation. Annual sardine landings in Portugal keep oscillating around the 80 Kton, on the assumption of unrestricted total catches.
2. **The pessimistic scenario**. It is an extreme scenario corresponding to a strong reduction of the stock level, thus creating the conditions for the adoption of precautionary measures. Annual landings reach a total of 41.5 Kton on the domestic wholesale fish markets, meaning a reduction of approx. 50% on the 1997 figures.
3. **The intermediate scenario**. It is a negotiation scenario, where a number of variables — political, economic, social and biological — play a relevant role. The total annual supply amounts to 61 Kton on the domestic wholesale fish markets, corresponding to a reduction of approx. 25% on the 1997 figures.

3. DYNAMIC MODELLING OF INDUSTRY

3.1 METHODOLOGY

The assessment of the impact of sardine scarcity within each scenario was carried out using a system dynamics model and computer simulation.

System dynamics was developed by Jay W. Forrester at the MIT (Massachusetts Institute of Technology) in the early sixties (Forrester, 1961), for the quantitative study of social and economic systems, resorting to the control systems theory, widely applied to mechanical and electromechanical devices at that time.

According to system dynamics theory, the structure of a system can be represented by a complex network of feedback loops, connecting stocks and flows. Values of the stock variables result from the time integration of the associated flows. System behaviour is related to the stock levels, and these determine the flow values in accordance with pre-established rules. System evolution patterns — exponential growth, oscillating movement, "S" curve, damped curve, etc. — depend on the feedback loops network and on which type of loop is dominating — either the positive (virtuous or vicious) loops or the negative (balancing) ones.

Once the model has been built and validated, it can be used to simulate the system behaviour in face of external events affecting its variables. Given the existence of multiple feedback and feedforward loops and time delays, the behaviour of a complex system — or of one of its variables — can only be determined and analysed by computer simulation.

In this paper, the modelling of the Portuguese canned sardine industry and the simulation of its behaviour within each scenario were carried out using Vensim software, developed by Ventana Systems Inc..

3.2 MODEL ASSUMPTIONS

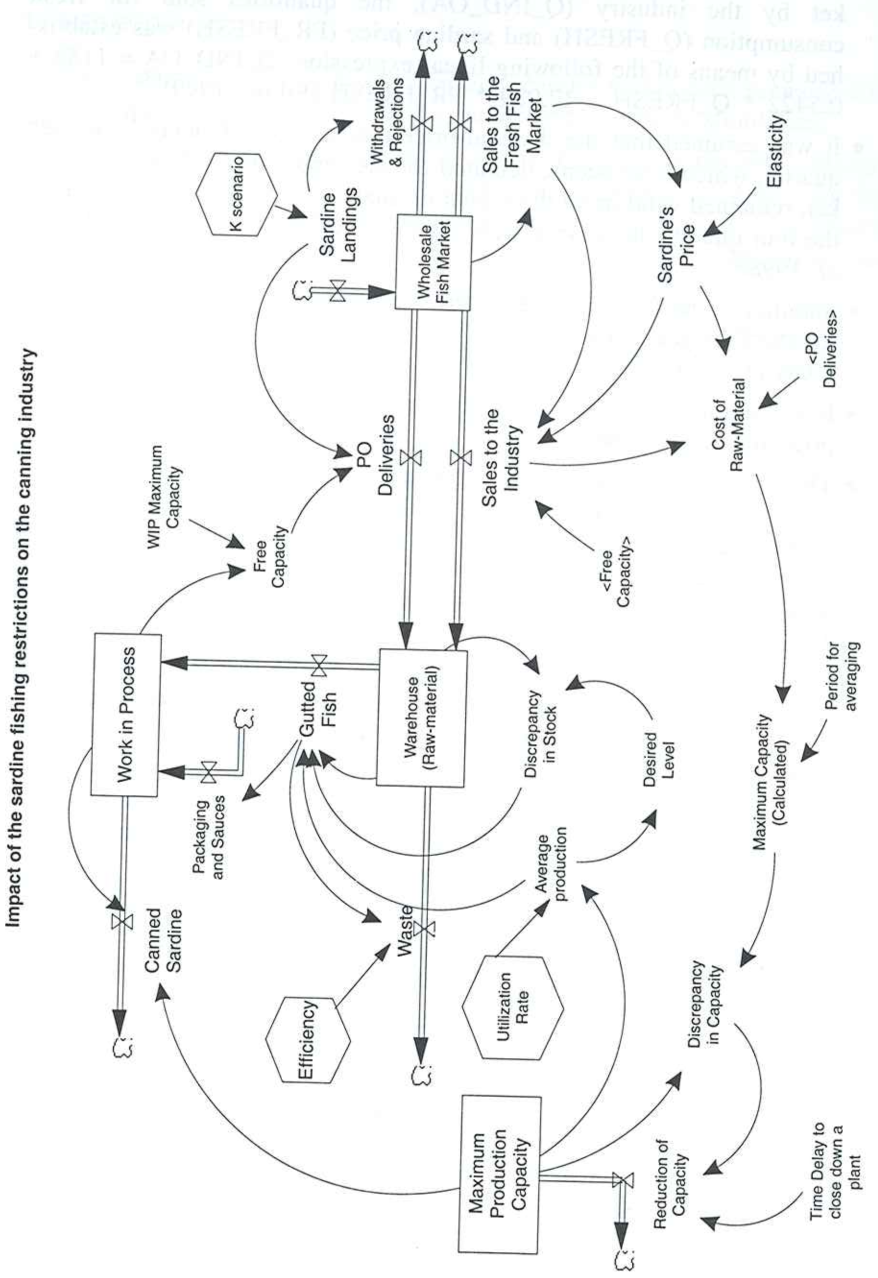
The disparities in the way the different sources organised the information about Portuguese fisheries and canning industry made a data harmonisation necessary which was validated by industry experts. The main assumptions incorporated in the model are as follows:

- Industry is exclusively supplied by fish landed in the Portuguese harbours; purchases are made either at the wholesale fish markets — in competition with the suppliers of the fresh fish market which is, at present, an auction procedure — or within the context of an annual agreement with the PO. The annual total bought from the PO cannot exceed 40% of the total sardine landings.
- Rejections and withdrawals were estimated as 6% of the landings, which is the average for the period 1995-97.

- The relation between the quantities purchased at the wholesale fish market by the industry (Q_IND_OA), the quantities sold for fresh consumption (Q_FRESH) and sardine price (PR_FRESH) was established by means of the following linear expression: Q_IND_OA = 1188 + 0.5422 * Q_FRESH – 12.989 * PR_FRESH (Filipe, 1999)[3].
- It was assumed that the demand-price elasticity coefficients[4] in each quarter, which have been calculated for the supply of the fresh fish market, remained valid in all the scenarios analysed. The values obtained for the four quarters are respectively –0.965, –0.929, –0.634, 1.061 (Dias *et al.*,1998b).
- Stability in the fish catching pattern was assumed. The seasonal indexes for the four yearly quarters are respectively 0.131, 0.208, 0.367, 0.294 (Dias *et al.*, 1998b).
- It was assumed that the canned fish was immediately sold, with a sales price identical to that of 1997.
- The total installed production capacity was estimated at 37.7 KTon, i.e. 1.5 times the total canned sardine produced in 1997. Future alterations of that capacity — either by investment, rationalisation or obsolescence — were not taken into account, except the reductions concerning plants where the production of canned sardine has become inviable (even when the plant has a multiproduct capability).
- It was assumed — in accordance with Reg.(CEE) 2136/89 — that gutted fish accounts for an average 70% of the canned sardine net weight and that the sardine efficiency rate (weight of fresh fish divided by weight of canned sardine) is 1.67.
- It was considered that average production rate, stabilised by the chilling and freezing methods, is 46% of the maximum production capacity (which equals 70% of the capacity used in 1997).
- The amount of sardine being processed was modelled as a work-in-process stock, with a specified upper limit; whenever the work-in-process reaches this maximum, the industry suspends its purchases for a while.
- Plants with an annual production of canned sardines above 29 Ton were divided into three groups D, C, B, in ascending order of efficiency. This efficiency was estimated taking into account the productivity and rentability levels. The plants were then ranked within each group, according to their survival potential which was established on the basis of the economic and financial information available.

  Based on the balance sheets and financial statements of some plants, a threshold of maximum acceptable cost of raw material was set for each group. Taking the price of the sardine at the wholesale fish market as the reference cost, the limits for the groups D, C and B were 105, 115, 150,

Figure 2: Stocks and flows diagram



PTE/Kg. When the six-months average cost of the raw material exceeds one of the thresholds, the plants of the group concerned begin to close down, irreversibly.

- The feedback on the fishing activity due to the alterations in industry demand — which may be of relevance at certain wholesale fish markets — was not taken into account.

3.3 THE MODEL

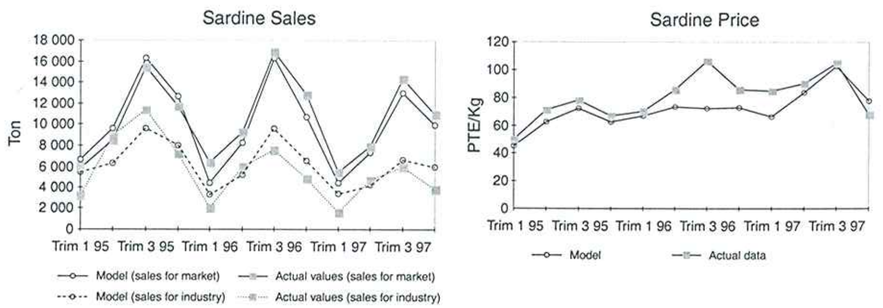
The model consists of three sub-systems: (1) the wholesale fish market with its price mechanisms, which determines the quantities sold to the industry and to the fresh fish market; (2) the industry capacity sub-system, where the number of plants that remain active is determined by sardine price and companies survival potential; (3) the canning process which, taking into account the fish quantities and the production capacity available at each moment, calculates the canned fish produced.

A simplified stock and flow diagram of the integrated model is shown in Figure 2.

3.4 MODEL VALIDATION

The model was tested by feeding in the 1995, 1996 and 1997 actual landing values. The results for the annual totals, which are presented in Figure 3, meet the requirements for this kind of model; the price deviation in the third quarter of 1996 is due to anomalous prices registered at some places.

Figure 3: Model validation



4. RESULTS OF THE SIMULATIONS

The exploration of each scenario, using the system dynamics model within the framework defined by the assumptions mentioned above, was done for a three year time period.

The evolution of the main variables is presented in Figure 4 (see the next page).

The installed capacity undergoes a drastic reduction in all the scarcity scenarios; the resulting values are presented in Figure 5.

Figure 5: Evolution of the Maximum Annual Production Capacity (ton)

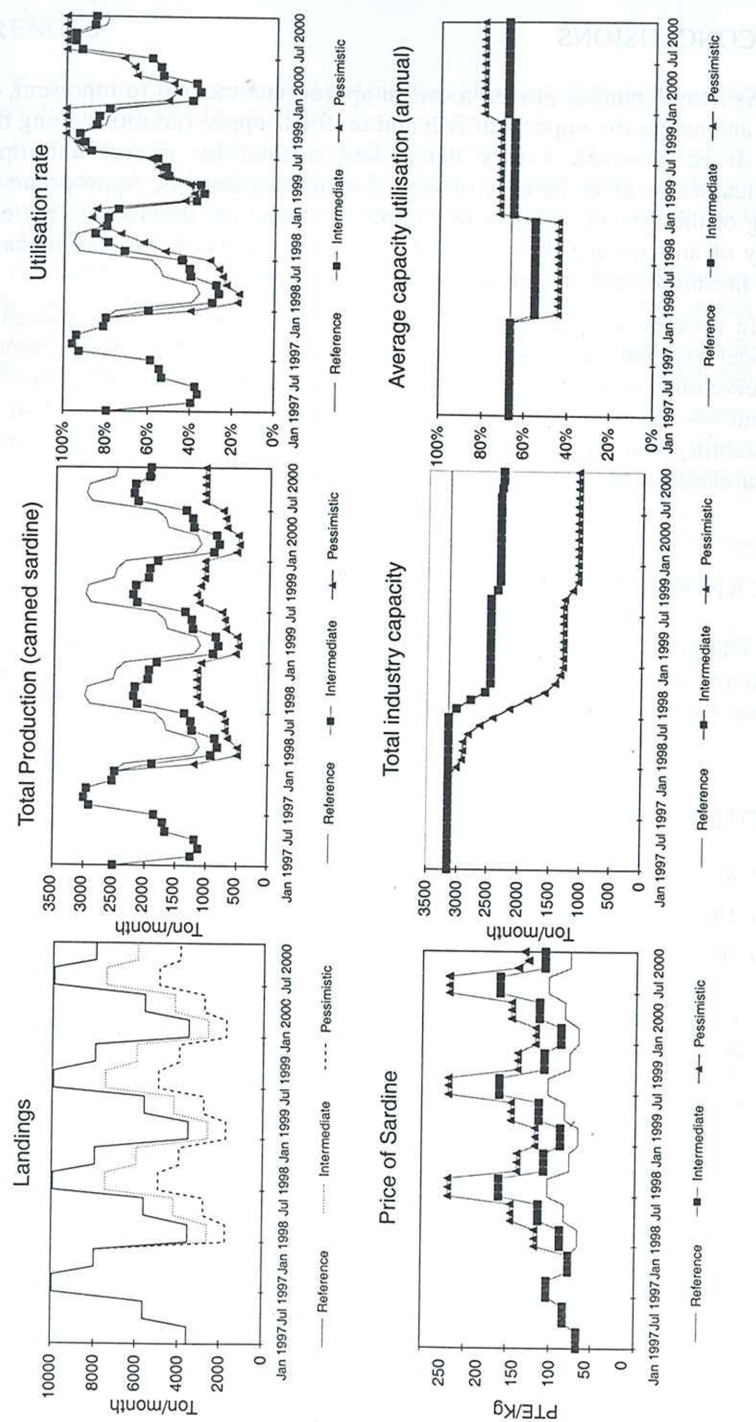
Year	Optimistic	Intermediate	Pessimistic
1998	37 692	29 568	16 020
1999	37 692	27 900	12 660
2000	37 692	27 360	12 660

The division of the production plants in the D, C and B groups and its ranking within each group as a function of its survival potential, make it possible to link the production capacity reductions and actual companies, plants and locations; therefore, the assessment of impacts at a regional level becomes a straightforward exercise.

The main conclusions of the impact assessment were:

- In the intermediate scenario, the sudden reduction of 25% in the fish supply brings about an equivalent reduction in the canned sardine produced and a 27% reduction of the installed capacity. An irrelevant increase of the utilisation rate in the remaining plants is observed. The total redundancies will amount to 930.
- In the pessimist scenario, the drastic reduction of 50% in the fish supply brings about a 60% reduction in the canned sardine produced and a reduction of 66% of the installed capacity. In the remaining plants, a large increase of the utilisation rate — from 67% to 80% — occurs. The job losses will amount to 1580.
- The instability at the wholesale fish markets will favour the supplying channel within the context of the agreement between the PO and the industry, which will tend to be hegemonic. At certain moments, the closing down of a plant may provoke strong instability at the local wholesale fish market, causing a further reduction in the local supply.
- At council level, job and income reductions are, with few exceptions, of little relevance.

Figure 4: Evolution of the main variables in the simulation period and in the three scenarios.



5. CONCLUSIONS

System dynamics proved to be an appropriate method to represent, visualise and assess the impacts of fish and seafood supply variations along the chain. It is, however, a very demanding method for market and operation indicators — as is the case of the elasticity coefficients. Appropriate modelling of the system, along with computer simulation, provides a very efficient way of anticipating the effects of different policies of resource management on the biological, social and economic variables.

In another perspective, it is important to recognise the role played by the model exploration through simulation, in the negotiation process among the intervening parts. The visibility of the feedback related to each player's behaviour — as is the case of the very strong link between the fish market instability and the closing-down of nearby canning plants — reinforces the awareness of their interdependence and makes the dialogue easier.

ACKNOWLEDGEMENTS

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NOTES

(1) Association of fishing ship owners, promoted by EU regulations.

(2) The Portuguese Institute for Fisheries and Sea Research.

(3) The regression and all of its coefficients are significant (sign F= 0.0000, sign T<0.05) and has an adjusted $R^2 = 0.44769$. Colinearity among the independent variables was not found.

(4) Using elasticity coefficients, it is possible to calculate the average sardine price from the quantities sold for consumption in fresh by means of the relation: $P / P_0 = (Q / Q_0)^{1/\varepsilon}$. P_0 and Q_0 are parameters defined for each quarter: P_0, 85.4, 82.3, 96.5 and 73.4; Q_0, 1150, 2480, 4516 and 3527.

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