System Dynamics Teaching at a Japanese University

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Abstract

For about 20 years I have taught System Dynamics modelling at a seminar cource, faculty of commerce, Meiji University, Tokyo. About 6-10 sophomore students used to be divided into 2 groups and each group chose an optional company or an urban city, for which students tried to formulate a System Dynamics simulation model, and its results were seen every year in a magazine published in Japanese by the faculty of commerce, Meiji University. There were about 30 papers of students, for such companies as super-market, watch, drugs, newspaper, transportation, brewery, bank, gas, restaurant, tobacco, airline, and so on, or for a suburban city near Tokyo.

Students gathered historical data, had interviews with objective coorperations, formulated models, for which they analysed feedback loops and simulation results. They did all by themselves. These systems thinking studies were of very much value for students.

I will explain a few examples from my student's works and some other Japanese research case studies.

1. Introduction

I attended the course of Industrial Dynammics I by Dr. Carl V. Swanson in 1966, and the course of Industrial Dynamics II by Professor Edward B. Roberts in 1967 at MIT. Soon after my return to Japan, I began to teach Industrial Dynamics at Meiji University, Tokyo. For aboout 20 years I have taught System Dynamics modelling at the university. Students used to be divided into 2 groups and each group chose an optional company or an urban city. Their simulation results were published every year in a magazine in Japanese by the university. There were about 30 papers of students, for such companies as super-market, watch, phermaceutic, newspaper, record, security, transportatiom, brewery, bank, gas, restaurant, tobacco, airline, and for a suburban city near Tokyo.

I will explain here 3 examples of an electric railway company, a suburban city of Tokyo and a super-market chain.

2. Model of an Electric Railway Company (monthly model)

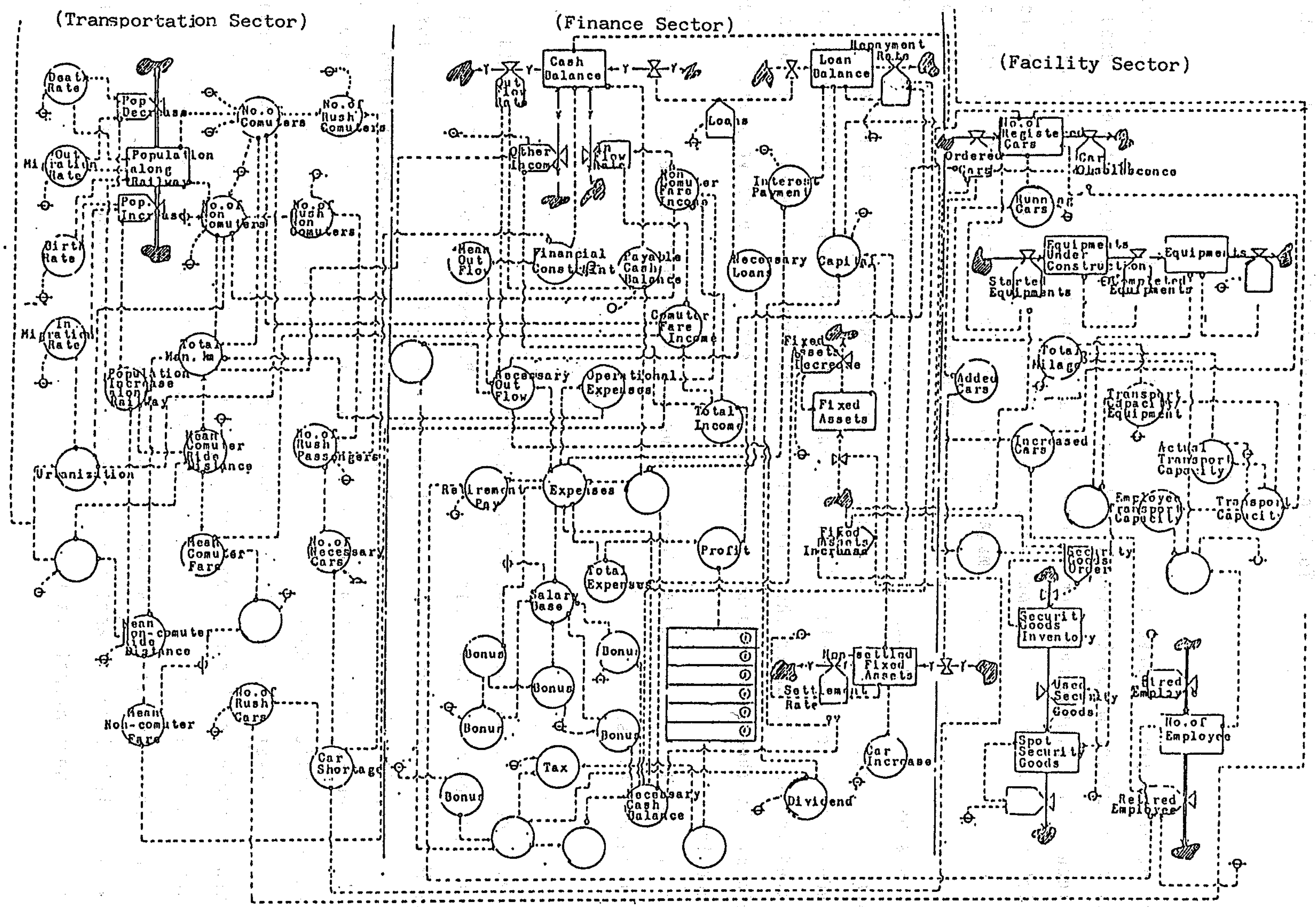

Fig.1 Flow Diagram of an Electric Railway Company

2.1. General Condition

This company is an electric railway company connecting a center station of Tokyo, with Kanagawa and Shizuoka prefectures and as side businesses, pursues real estate, car parks, recreation parks, travel agency and highway buses.

2.2. Present Condition

This company plans a few new lines, so it is important to investigate about future financial conditions, relating to new lines and real estate development along new lines.

2.3. Parts of the Model

This model contains 3 sectors of transportation, facilities and finance.

2.3.1. Transportation Sector

This sector contained population along the railway, number of passengers, car shortage, urbanization, mean fare and so on. Increment of transport capacity in the facility sector accelerated urbanization, which, on the one side, increased population along the railway, on the other side, urged the ride distance of passengers. Increment of population along the railway increased passengers and then car shortage appeared. Increment of mean ride distance accelerated mean fare increase and consequently the total income in the finance sector increased.

2.3.2. Facility Sector

In this sector students treated number of registered cars, security goods, equipments, number of employee, and transport capacity. The number of registered cars increased owing to car shortage from the transportation sector and financial constraint from the finance sector. The increment of registered cars urged to increase security goods, equipments and employee. These changes affected transport capacity which was connected with urbanization in the transportation sector.

2.3.3. Finance Sector

Various expenses flowed into this sector from the facility sector and from the transportation sector various income flowed into this sector. The difference between the total income and the total expenses were added to the company cash balance and decided the total profit. The cash balance affected financial constraint, which was connected with the number of registered cars in the facility sector.

2.3.4. Simulation Results

The simulation was run for 30 years from 1961 to 1991 and DT was one month. This model was the first model, which was simulated by my students with DYNAMO about 20 years ago. The simulation results were not considered to show good fitness to the actual data, but 8 students put their energy into this model and had incomparable experiences.

3. Model of a Suburban City of Tokyo (yearly model)

3.1. General Condition

This city is a suburban city along the Bay of Tokyo, about 70 km to the east of Tokyo, with about 110,000 residents. The Tokyo Metropolis is too much crowded to live, so the population of suburban cities is gradually increasing. The populatiom of this city became twice as many as ten years ago. Students tried to formulate the SD model for this city and made a research on some policies.

3.2. Present Condition

The increment of the population caused the explosive increase of financial demand of the city. This was mainly because of new buildings of elementary or junior high schools. The city planned to reclaim land from the sea for residences, industrial and commercial land, public services and recreation grounds.

3.3. Parts of the model

This model has 3 sectors of population, finance and city attractiveness.

3.3.1. Population Sector

Total population was divided into 4 classes, 1) infants (0-6), 2) pupils of elementary schools (7-12), 3) pupils of junior high schools (13-15), 4) 16～ years of age. The population varied with social increase between in- and out-migration, and with natural increase, that was, excess of births over deaths.

3.3.2. City Attractiveness Sector

In this sector students treated the comparison between this city and Tokyo Metropolis in regard to rate of demesne, land price and water pollution.

3.3.3. Finance Sector

The revenue consisted of city rates, allocated tax, grants from the national

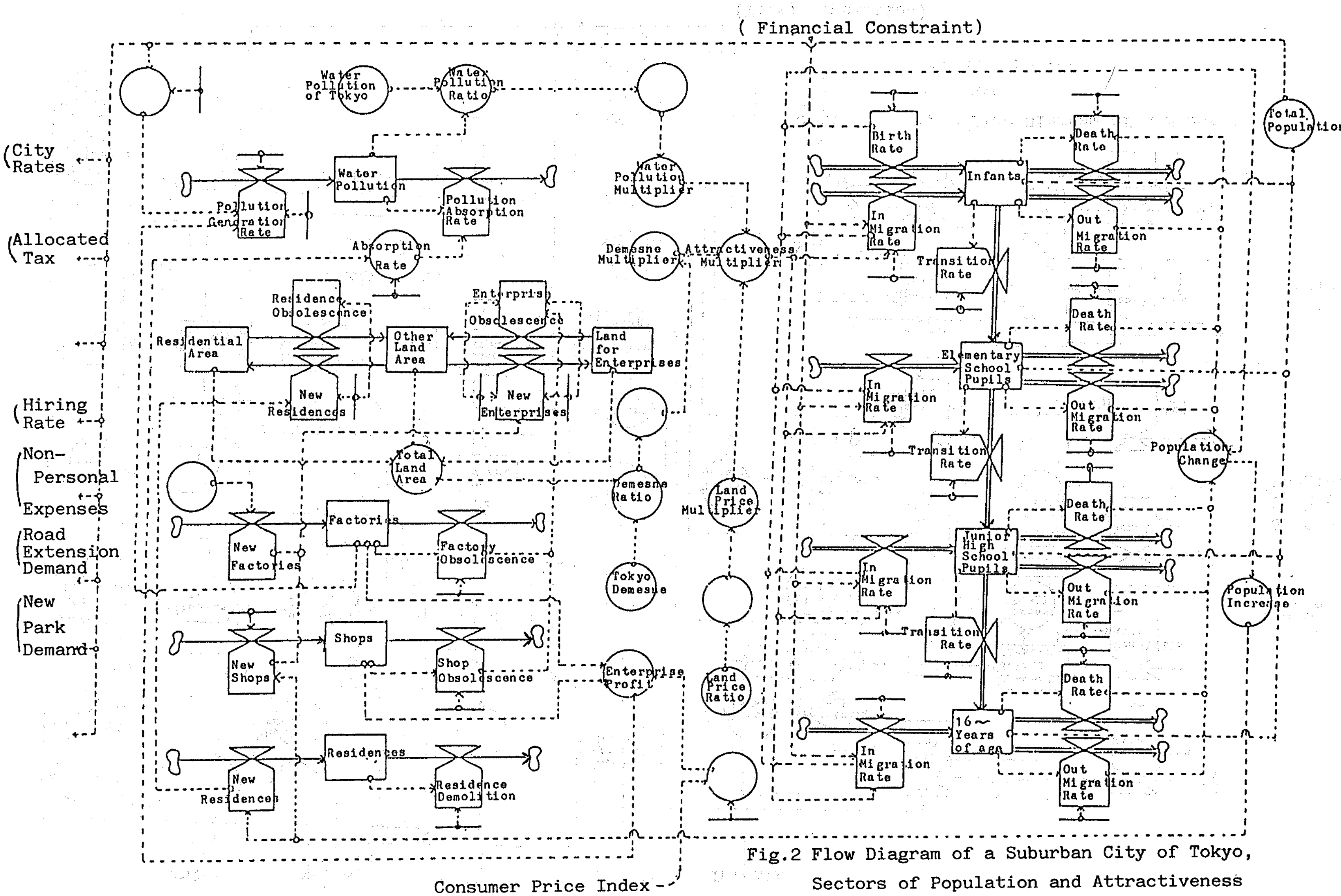

Fig.2 Flow Diagram of a Suburban City of Tokyo, Sectors of Population and Attractiveness

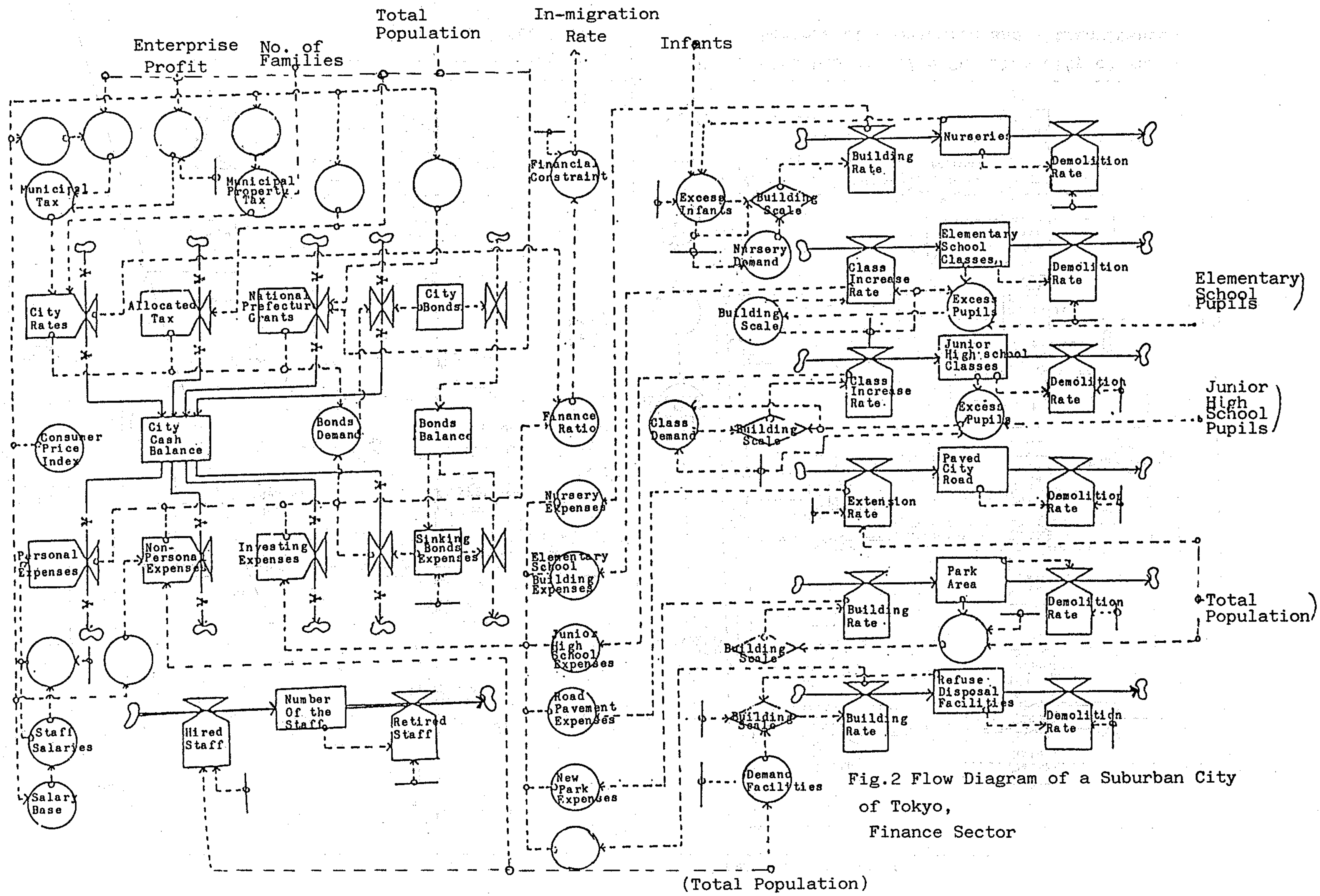

Fig.2 Flow Diagram of a Suburban City of Tokyo, Finance Sector

and the prefectural governments, and city bonds. On the other hand, the annual expenditure consisted of personal expenses, non-personal expenses, investing expenses and sinking bonds expenses.

3.3.4. Simulation Results

The simulation was run for 30 years from 1965 to 1995 and DT was one year. About ten years ago, this city reclaimed land from the sea and developed a large scale apartment area. Students formulated this model before this development and made a research on expected changes beforehand.

4. Model of a Super-market Chain (yearly model)

4.1. General Condition

This super-market chain opened the first shop in Osaka city in 1967, when the number of employee was 13, the floor area was 53 m^2 and the capital was ¥ 4 million. 12 years later the sales exceeded ¥100 billion and now this company is the biggest retail store chain in Japan.

4.2. Present Condition

This company intended to develop a retail store chain of low price = bulk sales. For this purpose, a central buying system has been established, and the company has set up several distribution centers, from where goods are delivered to each shop. 3 management policies came to question. First was hiring policy. Personal expenses were an important factor of financial conditions of this company, so the number of part-time employee was increased to improve financial conditions. Second was to decrease distribution cost by means of rationalization of distribution system. As the number of shops increase, facilities of distribution centers may be magnified and delivering cost may be saved. Third was controling policy of loans. If this supar-market chain kept the policy of developing many shops, it would have an important means to decrease loan interests.

4.3. Parts of the Model

This model has 4 sectors of facilities, finance, distribution and hiring.

4.3.1. Finance Sector

This sector was based on securities reports of this company. The cash balance was added by the annual sum of income, such as sales income, income by real property, loans, received dividends, convertable bonds, added stocks, and so on, minus the annual sum of expenses, such as buying goods expenses, personal expenses, operational costs, paying interests, repayment loans, facility expenses, dividends, tax and so on.

4.3.2. Financial Constraint

Financial constraint was set equal to smoothed loans divided by smoothed cash balance of the company. This variable had an influence on loans, loan repayment, capital increase, or issue of bonds.

4.3.3. Hiring Sector

The employee were divided to full-time employee and part-time employee. In recent years this company refrained from hiring new full-time employee and plomoted to hire part-time employee. In this sector students treated to analyse the policy of attaching importance to part-time employee.

4.3.4. Distribution Sector

In this sector students analysed the distribution system from makers to shops of this chain, centering around distribution centers, and treated customers, inventory at shops and distribution centers.

4.3.5. Simulation Results

The simulation was run for 20 years from 1972 to 1992 and DT was one year. The expense by way of distribution centers / good were always lower than the margin of wholesalers / good. Students recommended that this super-market chain should continue to increase facilities of ditribution centers, and they advised a few other improvemental policies.

5. Conclusion

I explained 3 examples from student's works. The first was the model of an electrtic railway company, connecting a center station of Tokyo with 2 neighboring prefectures. The second was the model of a suburban city of Tokyo. This city is along the Bay of Tokyo with about 110,000 residents. The third was the model of a super-market chain. This chain is now the biggest company of retail trade in Japan.

Students gathered historical data, formulated models and analysed feedback loops in the model. They did all by themselves and had incomparable experiences.

I think, System Dynamics is the best way for students to try to formulate models of real systems and to understand the system structure of those systems.

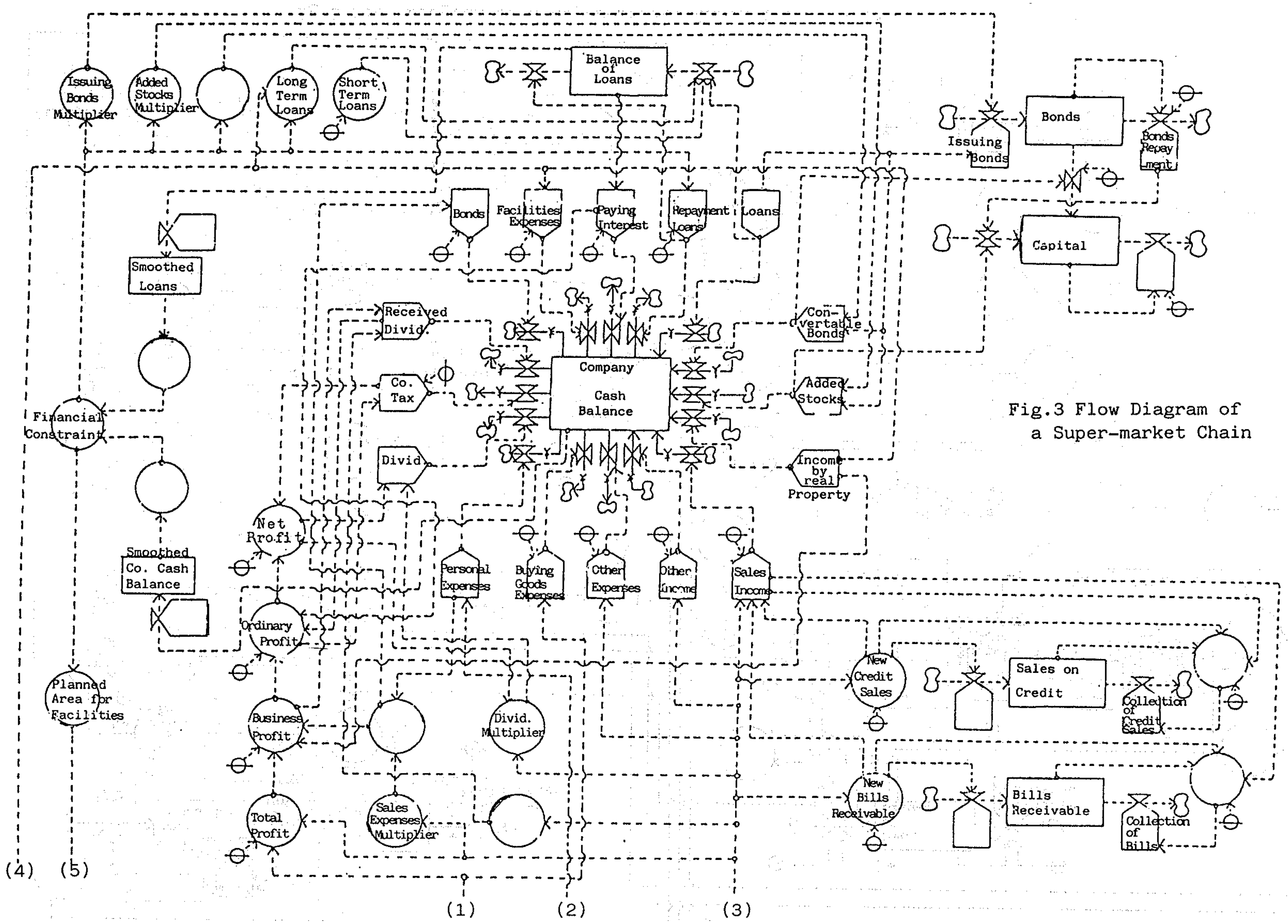

Fig.3 Flow Diagram of a Super-market Chain

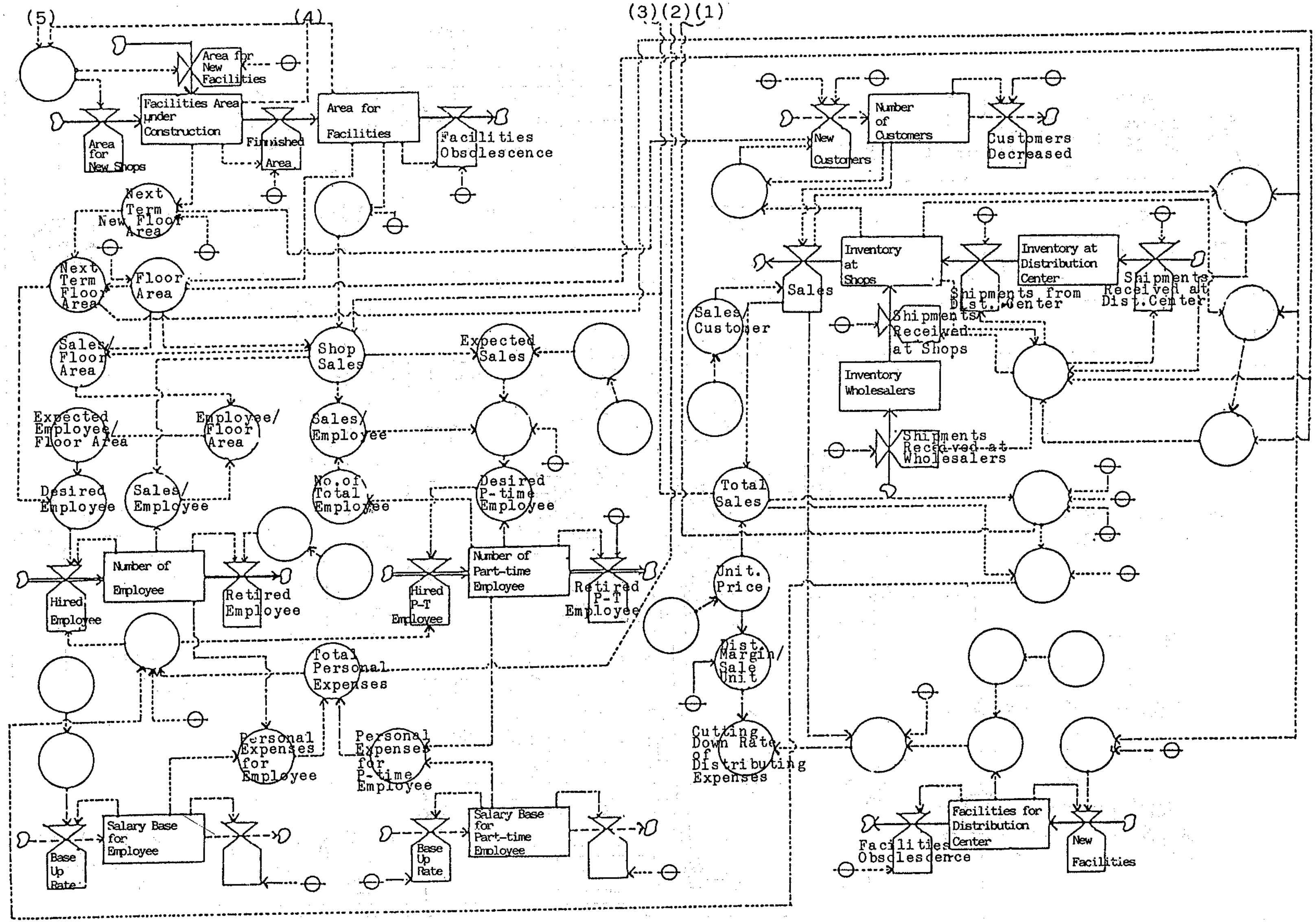

Fig.3 Flow Diagram of a Super-market Chain (continued)