MODELING THE DIFFERENCES AND CONFLICTS BETWEEN NORTH AND SOUTH IN THE CONTEXT OF GLOBAL SUSTAINABILITY

ABSTRACT

Today, the world is divided into two main blocks: Developed nations with excess capital, or North, and developing nations with excess labor, or South. It is a widely accepted fact that interactions and conflicts between these two blocks play a major role in the context of global sustainability. In this paper, a global SD model with North-South differentiation is built in order to investigate the long-term outcomes of certain policies regarding interactions between these blocks (such as natural resource transfers, capital investments, external debt, immigrations, and trade) in terms of welfare distribution, global persistent pollution, population growth and non-renewable resources. In modeling the world with a North-South differentiation, certain structures and assumptions of WORLD3 are used as a starting point. Causal structure of the model is completed and research is currently at the stage of equation writing and parameter estimation.

BACKGROUND INFORMATION AND PROBLEM DEFINITION:

It was late 18th century when the first striking discussion about the sustainability of mankind first aroused. It was Thomas Malthus with his *Essay on the Principle of Population* (1798), who stated that in nature plants and animals produce far more offspring than can survive, and that Man too is capable of overproducing if left unchecked.

In the centuries following this article, sustainability of the human development on earth became subject to many discussions. Especially in the second half of the 20th century, sustainability of the current pace of development became a hot issue. Although mankind was experiencing a continuous growth in population and economy, there were certain doubts about the sustainability of this growth. In short how many generations of mankind will this earth be able to support with the current level of welfare? Several studies pointed to issues like pollution, exhaustion of natural resources, poverty regarding the sustainability of current mode of growth. Although there is no agreed upon conclusion on the issue, it is estimated that current pace of economic and population growth are not sustainable. Factors like food, natural resources, pollution, population, and distribution of welfare seem to be key issues in this context and set the limits to human development.

Among numerous studies conducted on the issue, global models WORLD2 (Forrester, 1971) and WORLD3 *(Meadows et al. 1974)* attracted much attention among both academic societies and public. These pioneering works of sustainability studies and system dynamics included the interactions between natural resources, food, population, economic activities and pollution. Results were striking when published in a report, namely *The Limits to Growth (Meadows et al. 1972)*. According to these results a sudden decrease in population was expected in near future as a result of reaching one of the many limits of development (pollution, food, land, etc), in a finite

world. These models covered ecological and economic dimensions of sustainability, but a third dimension which deals with equity and disparity is ignored, which is the social dimension.

It is a widely accepted fact that world is divided into two main blocks according to the distribution of welfare. Developed nations, or *North*, stand as the block with intensive capital, stable population and high welfare levels. On the contrary, developing nations, or South, have excess labor, increasing population, low capital and low welfare levels. It was assumed in the past that all undeveloped nations will follow the same growth path once currently developed nations passed and transform into their developed states. However, today it is known that it is very unlikely for the undeveloped nations to follow the growth path observed in developed nations' history. Their development will probably follow a different path and the highest peak they can reach may not be the developed block's current level.

Additionally, the obvious welfare gap between these two blocks seem to widen day by day and it is claimed that conflicts between these blocks due to this gap will be the key factor in the sustainability of development. These conflicts have a great importance in determining the nature of interactions between these two blocks, such as natural resource transfers, capital investments, immigrations, and trade. So distribution of welfare stands as a challenge for the sustainable development policies, as well as managing factors like pollution, population and resources.

Due to these facts, it is seen that social issues are more important than it has been believed. Frictions due to social tension should be seriously considered, otherwise there is unsustainable social tension, which slows development and in the worst case leads to violence and destruction *(Randers, 2000).*

A policy regarding the sustainable development should be evaluated according to pollution levels, economic activity, resource scarcity and food scarcity (as WORLD3 did). However, distribution of these factors among North and South is another criterion as important as others.

MODEL STRUCTURE

The model is composed of five major sectors (population, non-renewable natural resources, persistent pollution, agriculture, and industrial production) and three supplemental sectors (monetary transactions, technology and job).

The structures of major sectors are mainly inspired by WORLD3, and apart from structures regarding North-South interactions only minory modifications are done.

As this project is concerned with the effects of inter-block (South-North) relations on global sustainability, main focus is on introducing structures that represent the inter-block relations that have the potential to change dynamics of growth in both

blocks. As a result, inter-block relations such as trade, foreign direct investment, non-renewable resource transfers, foreign debt and aid are introduced.

In this section structures related to these inter-block relations and underlying assumptions are discussed. Modifications on the original structure of WORLD3 will also be mentioned. For the earlier structures and assumptions *Dynamics of Growth in a Finite World* (Meadows et al. 1974) provides an essential documentation.

a. Population

Prevailing trends in populations of North and South differ considerably. Population of South demonstrated an exponential growth in the first period of the past century. As a result of effective birth control methods this trend seems to be stabilized (Cohen,1995). However, age structure of the South is mainly composed of young population and this indicates that momentum of the past growth rate will be in effect for a while. On the contrary, North has a stable and even in some specific cases declining population levels with an older age structure. This structure may result in a declining pattern of births and labor force in the future.

Structural Issues

In the model this sector is composed of two identical structures, each corresponding to a block. In order to capture the age structure and the momentum of the past growth rates, populations are modeled with a three-stock structure, as proposed in Dynamics of Growth in a Finite World (Meadows et al. 1974). Each of these stocks correspond to portions of population at pre-reproductive, reproductive and post-reproductive periods of lifetime. To be more precise, pre-reproductive period is defined to be ages lower than 16, reproductive period involves ages from 17 to 45 and post-reproductive period is above 45.

In WORLD3, social norms, perceived welfare level and birth control effectiveness are incorporated into the structure determining the fertility rate. In this research, for the sake of simplicity, desired fertility rate is determined by interactions of just two factors; perceived domestic income per capita and perceived death fraction in population portion at pre-reproductive stage. First of these determinants is used as an indicator for individual's expected level of welfare at old ages. As children represent the financial security for parents at old ages in most of the societies, desired fertility decreases as domestic income per capita increases, which means less need for external financial support. On the other hand, second determinant is an indicator of a child's probability of reaching reproductive age. As this probability decreases, desired fertility is proposed to increase (Aronson, 1976).

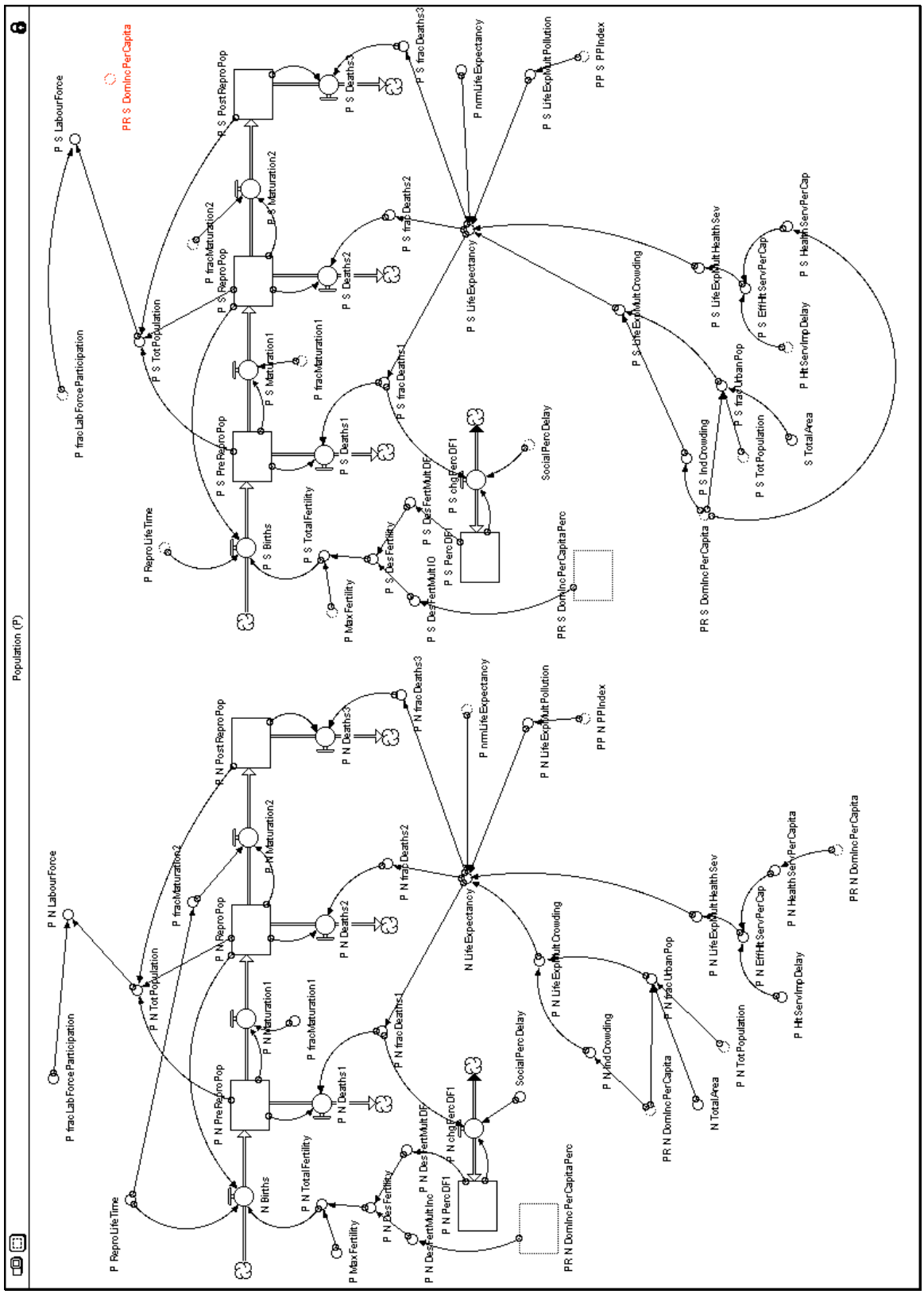

Figure 1: Stock-Flow Diagram of Population Sector

Migration is the inter-block relation related to population, but this flow between blocks is ignored in the model, considering the insignificancy of the migration figures compared to overall population figures. It is assumed that rate of migration will not have a major impact on overall dynamics and this is assumed to prevail in the future due to the strict migratory regulation existing especially in North block.

b. Industrial Production

Production dynamics play the major role in the context of this research. When the blocks are compared in this context, very different dynamic behaviors are observed and expected. First of all, level of accumulated capital in North is much more than South's. Additionally, productivity of this capital is higher in North due to the level of production technology employed. Combining these two facts, it is seen that North has the opportunity to maintain and even increase its current output and welfare level. South is expected to follow a similar development pattern and accumulate capital in time. However, missing point in the discussion is the difference between the situation of North in its developing era and current situation of South currently trying to develop. North maintained such an accumulation through exploitation of its colonies. On the other hand, South has no such opportunity of exploitation and even worse it faces a strict competition with developed North. Under these circumstances South most probably will follow an alternate development pattern than the one North followed in the past (Daly, 1999 and Mrydal,1964).

Complex interactions of production, trade, investment and technology will determine the outcome. Additionally, inter-block relations such as Foreign Direct Investment (FDI), trade and technology transfer are very influential in this manner.

FDI from North to South will exploit resources and create pollution parallel to an increase in overall welfare and technology level of the South. It is possible to observe a speed-up in development of South with the help of FDI and widening of the gap between North and South may stop, or it is possible that FDI leaves South after exploiting production factors and South can not generate capital growth during the existence of FDI and its development starts a collapse period.

Trade may provide extra financial sources to be used in new capital investments or in the inverse direction may exploit the income of the block and reduces the sources to be used in capital investment and results in a reduction in economic growth.

Technology plays a very important role in the economic growth. First of all, it provides increased capital productivity. Additionally, by reducing the resource usage and pollution generated per economic activity it pushes the pollution and resource limits further. Two mechanisms for technology development are considered. First of them is technology development via R&D activities and it is an endogenous process for blocks. On the other hand, other mechanism for

increasing technology level is through technology transfer. This includes the adaptation (through imitation) of technologies used in imported goods, or adaptation of technology and know-how coming with foreign investment. Speed of this transfer is dependent on the intensity of the foreign capital in an economy and volume of trade between blocks (Chudnovsky,1991). A coarse causal loop for production technologies is presented in Figure 3.

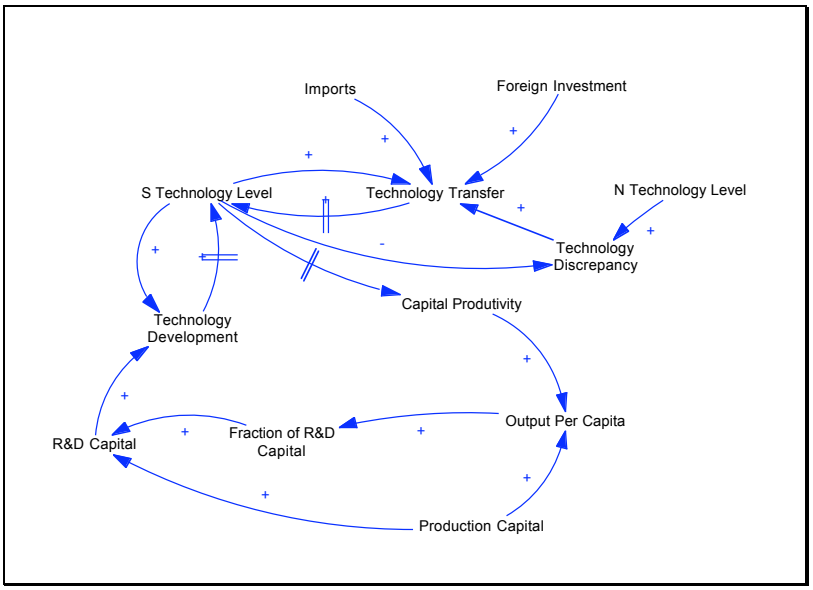

Figure 2: Causal-loop diagram for technology generation

Structural Issues

Main element of the production sector is production capital, with the same meaning as in WORLD3. This stock involves every factor used in production of output except labor and resources (machines, vehicles, buildings, etc).

In the model, it is assumed that some portion of this capital is allocated to R&D activities and obtaining resources. Hence, productive capital is less than the total available capital level. Fraction of capital allocated to obtaining resources is determined by extraction rate of resources and amount of resources available in the reserves. On the other hand, fraction of capital allocated to R&D activities is defined to be function of overall development, represented by domestic income per capita in the model.

Productivity of capital determined by four factors. Among them, level of resource conservation and pollution prevention policies were also existed in WORLD3. However, additional to those production technology level and capital deepening effect are introduced (these two were also considered in WORLD3, but with the assumption that their effects will offset each other they were not included explicitly). Effect of production technology level is an increased productivity per capita as technology level increases. On the contrary, capital deepening effect represents the reduction in productivity due to the increase in Capital/Labor ratio.

Physical output is transformed into monetary terms using an average price index and total domestic income from production is calculated. This variable is used to calculate income per capita, which represents the level of development in the model. Fraction of physical output exported and imported are determined as a function of this indicator.

For the South block, capital stocks of foreign investors are kept separately and it is called Foreign Capital, whereas rest of the production capital is named National Capital. This structure allowed monitoring foreign capital movements, output generated by this capital and finally profit of foreign investors, which in turn may be transferred to North or reinvested in South.

Blocks export some portion of their industrial production and also import some portion of other block's production. However, the model structure responsible for the determination of these amounts is more likely to be correlational than causal. Fraction of exports and imports to industrial production is determined by domestic income per capita and values from the cross-sectional and longitudinal studies of Chenery (Chenery, 1973) are utilized in this relation.

Considering that technology generates technology, rate of change in technology level is defined to be dependent on existing technology level. Finally, rate of change is dependent on the technology level discrepancy between blocks, as expected.

Amount of Foreign Direct Investment (FDI) flow to South is determined by three factors in the model. Two of them are prices of main production factors; labor and resources. Labor price is determined as a function of labor utilization fraction and resource cost is determined by the available resource reserve level. Third factor is the determination of FDI is a qualitative parameter, Pollution Restriction Level. This parameter represents the level of pollution awareness in a block and strictness of restrictions related to pollution generation (e.g. emission limits). Pollution Restriction Level is assumed to increase as the welfare level, represented by domestic income per capita in the model, of the population increases.

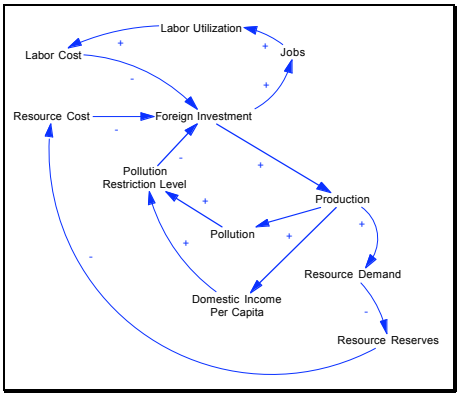

Figure 3: Causal Loop Diagram for Foreign Direct Investment

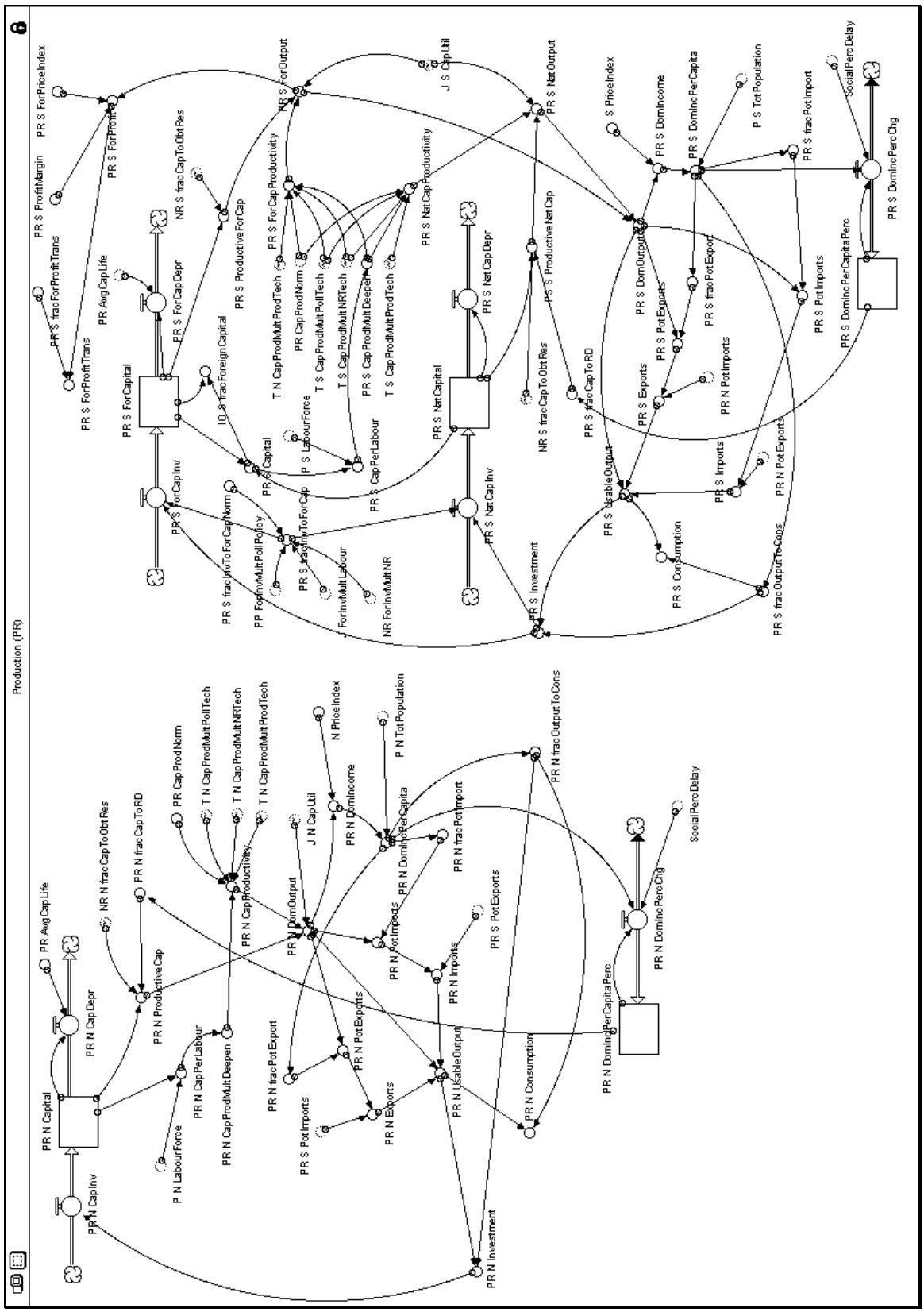

Figure 4: Stock-Flow Diagram of Industrial Production Sector

c. Non-Renewable Resources

Proposed dynamics in WORLD3 is increasing fraction of capital allocated to obtaining resources as a result of resource depletion, and as a result of allocating most of the resources to this process decline in industrial production. Underlying assumption is that most accessible ores will be exploited first and poor ores will remain at last. Naturally, this exploitation is a result of economic growth and there is a trade-off between exploitation rate and growth.

However, in a world with two blocks resource transfers may yield exploitation of the resources by the other block and this results in an exploited resource reserves and limited economic growth (Taylor and Copeland, 1994. Lofdahl, 2002). Lower welfare level of South block results in an undervaluation of its resources and lack of incorporating external costs to prices. This coupled with high resource demand of North, completes a structure suitable for exploitation of resources.

Hence, non-renewable resource transfers between blocks play the major role in determination of the dynamics of exploitation/growth theory. Figure 5 represents a coarse causal loop diagram for resource trade and related dynamics. Briefly, block with relatively less resource reserves satisfies a fraction of its demand from the other block's reserves by importing. Assuming that unit prices of resources are determined according to the availability of the resources, block with more resource reserves will have lower prices, and this price difference is the main factor determining the trade dynamics between blocks.

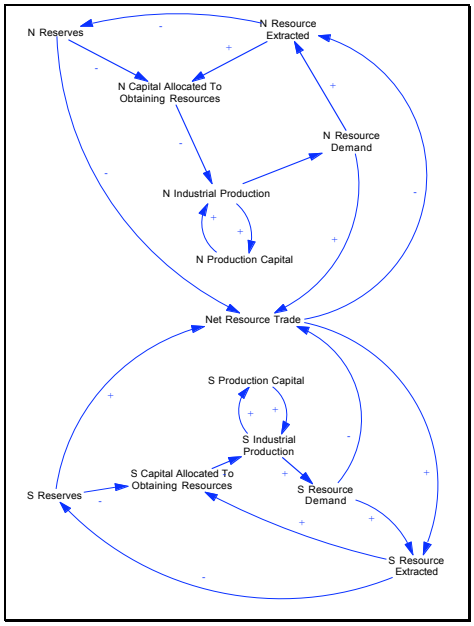

Figure 5: Causal Loop Diagram for Non-Renewable Resource Trade
Net Trade = (Imports from South to North) – (Imports from North to South)

Structural Issues
In the model some portion of the production capital is allocated to resource extraction and amount of this capital is determined by amount of resources extracted and level of the remaining resource reserves.

Considering these two, a South block with low resource demand and high reserve levels will be a perfect import source for North with high resource demand. The dynamics of this structure will be mainly determined by what South gets from North in return of resource trade. An undervaluation as in the current real status, will result in exploitation of resources of South by North and limiting the development of South.

Degree of availability of resources if defined by the ratio of available reserves to usage rate (namely AvailabilityRatio). This indicator with time units represents how many years could reserves last with the current usage rate. It is assumed that there exists a perception delay until industry and society recognizes real availability ratios. Value of availability ratio of a block relative to other block's determine the direction and volume of the resource trade. As in WORLD3, depletion of resource reserves triggers development of resource conservation technology development.

Stock-flow diagram related to this sector is presented in Figure 6.

d. Persistent Pollution
Major impact of increased pollution is on the productivity of land and life expectancy of populations. As a balancing structure it is accepted that increased pollution coupled with the pollution awareness level of the population triggers the mechanism for developing technologies that will reduce the pollution generated by production processes. Generated pollution shows its effect after an assimilation effect. Also it is expected that pollution generated within a block, will be transferred after a delay and effects will be observed in the other block, too.

Structural Issues:
Pollution generation rate is dependent on population, consumption level per capita and pollution generation properties of the consumed products. This is managed through use of three multipliers, namely Industrial Material Emission Index, Material Toxicity Index and Fraction of Resources composed of Persistent Material. In WORLD3, these multipliers were fixed, but in the scope of this research two blocks with differing production patterns are to exist together. Hence, these multipliers are defined to depend on development level of the block. As the domestic income per capita is used as an indicator for overall development, these multipliers are defined as a function of domestic income per capita.

As mentioned above, an inter-block pollution transmission flow is defined. This transmission rate is dependent on the discrepancy between blocks' pollution

levels and transmission delay, which is defined to be longer than the regional pollution transmission delay.

Rest of the persistent pollution generation and assimilation structures are identical with WORLD3.

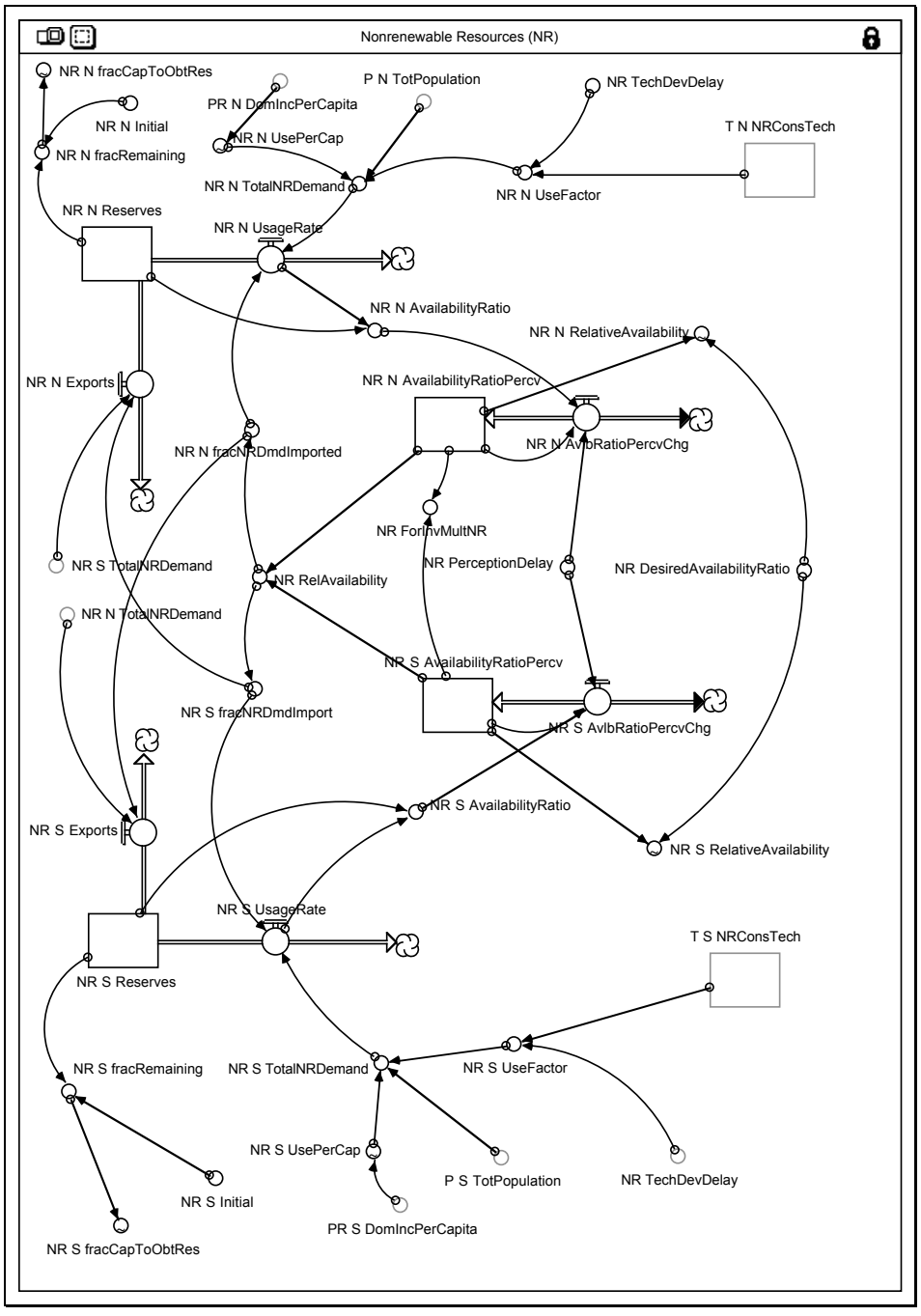

Figure 6: Stock-Flow Diagram of Non-Renewable Resources Sector

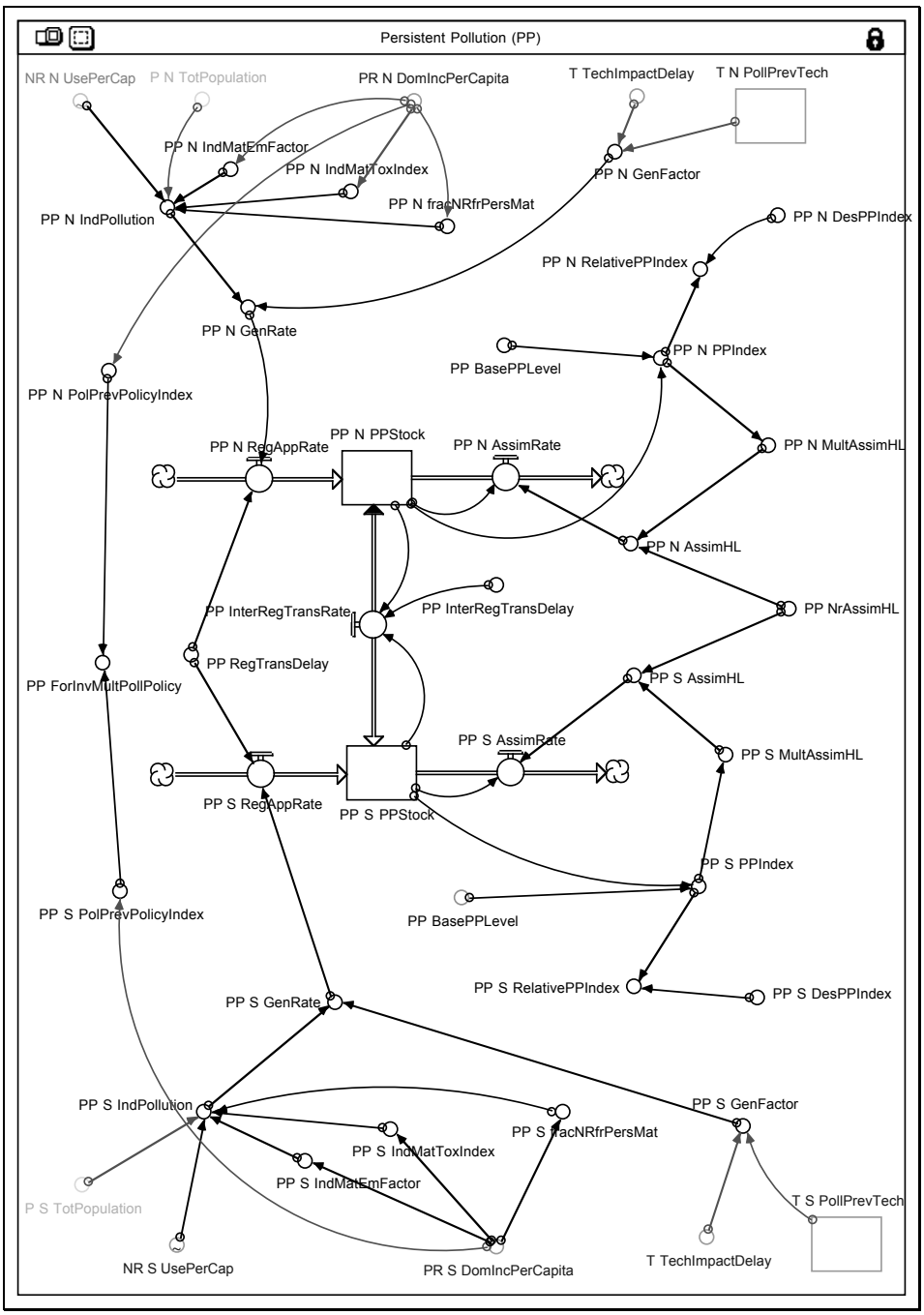

Figure 7: Stock-Flow Diagram of Persistent Pollution Sector

e. Monetary Transactions

As mentioned before inclusion of debt, trade balance and foreign investment issues required modeling the monetary flows between these two blocks. Main dynamics related to monetary flows is the dynamics of debt. Foreign debt related dynamics or 'debt trap' in other words play an important role in the development process of South. As presented in the causal loop back payments of outstanding debt restrict the investment to production capital which in turn expected to

generate income. At a certain point this relation results in the need for new debt for financing back payments. To sum up in a few words, high amounts of outstanding debt triggers the debt-for-debt mechanism, which is a killer loop for South.

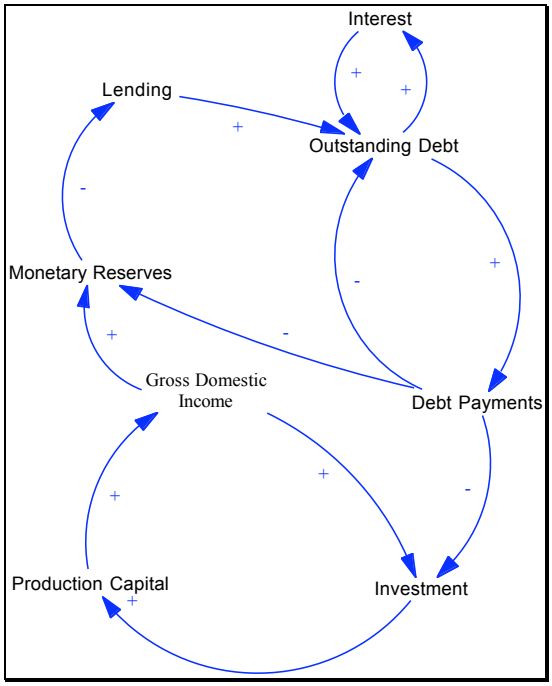

Figure 8: Causal Loop Diagram for Foreign Debt

Structural Issues:

This sector is completely composed of monetary variables that did not exist in WORLD3. Inclusion of flows such as trade, debt and aid required such monetary variables. In order to avoid complexities of financial markets, some simplifying assumptions are made. First of all, both blocks are assumed to use a single currency, which is defined to be US Dollars in the model. This assumption prevents any gain-loss due to exchange rate differences, but considering that time horizon of the model (100 years) is long enough to ignore gains and losses due to short-term fluctuations in the exchange rates. Additionally, effect of the inflation in the blocks is eliminated via money supply mechanisms. Each block is supplied an amount of money equal to the change in total domestic income.

Other than money supply flow, there exist 6 flows between blocks' monetary reserves. Trade balance is calculated using the export, import and price index values of each block. Direct investment flow is explained in the previous section. Profit transfers flow represents the profit transferred by foreign capital from host block to own block. Other two flows are related to foreign debt. Debtor block is assumed to pay as much as possible portion of the expected debt payment by sourcing this payment by new debt or own monetary reserves. Amount of expected payment that cannot be paid is charged with interest. This can be accepted as a re-scheduling situation. In borrowing new money, international

credibility of the block, which is calculated as a function of outstanding debt divided by total domestic income, determines the available funds.

A foreign aid flow is defined as a function of discrepancy between welfare levels of the blocks and the domestic income of the richer block.

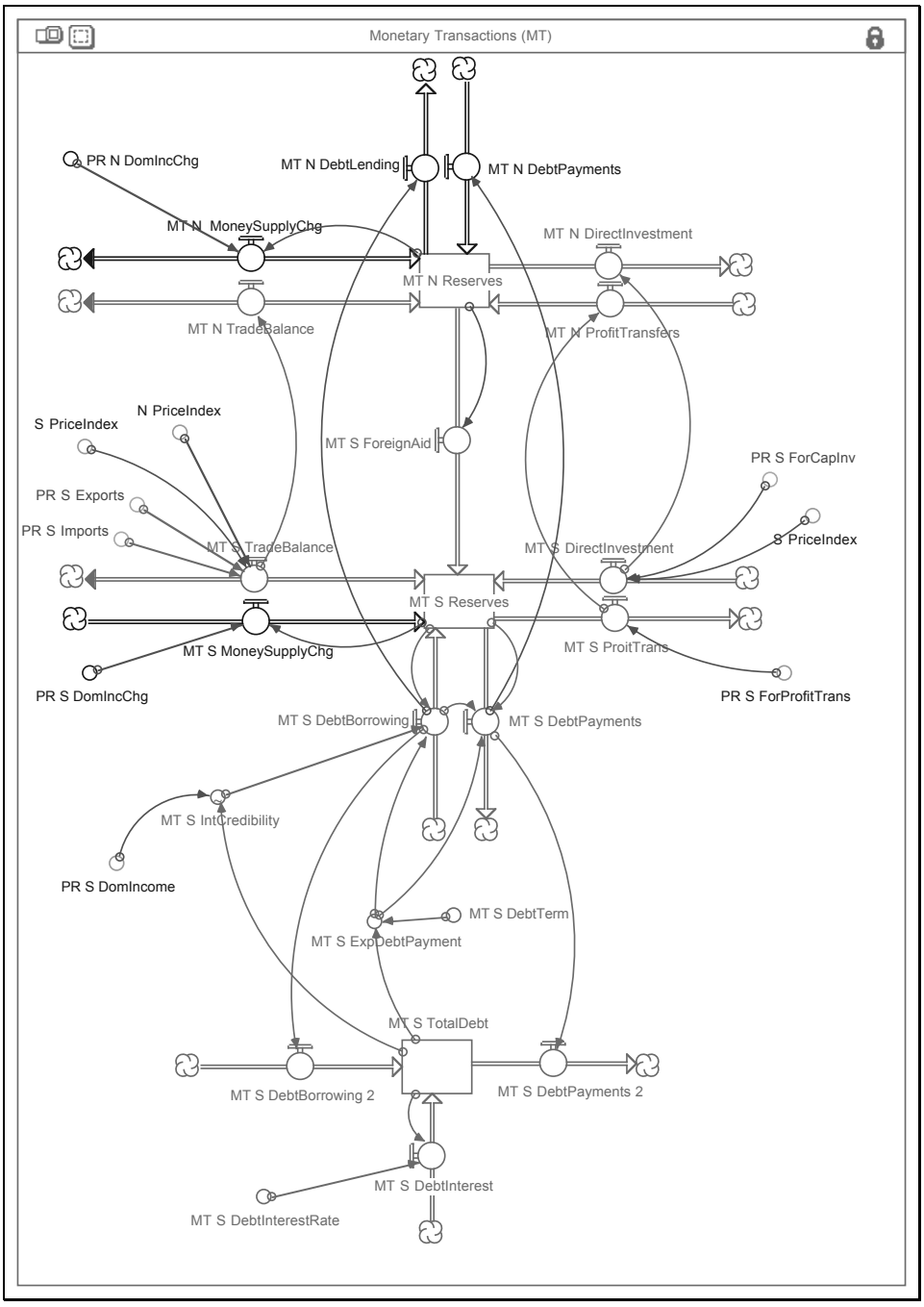

Figure 9: Stock-Flow Diagram of Monetary Transaction Sector

f. Technology

Expected behavior dynamics related to technological development is mentioned in the industrial production sector.

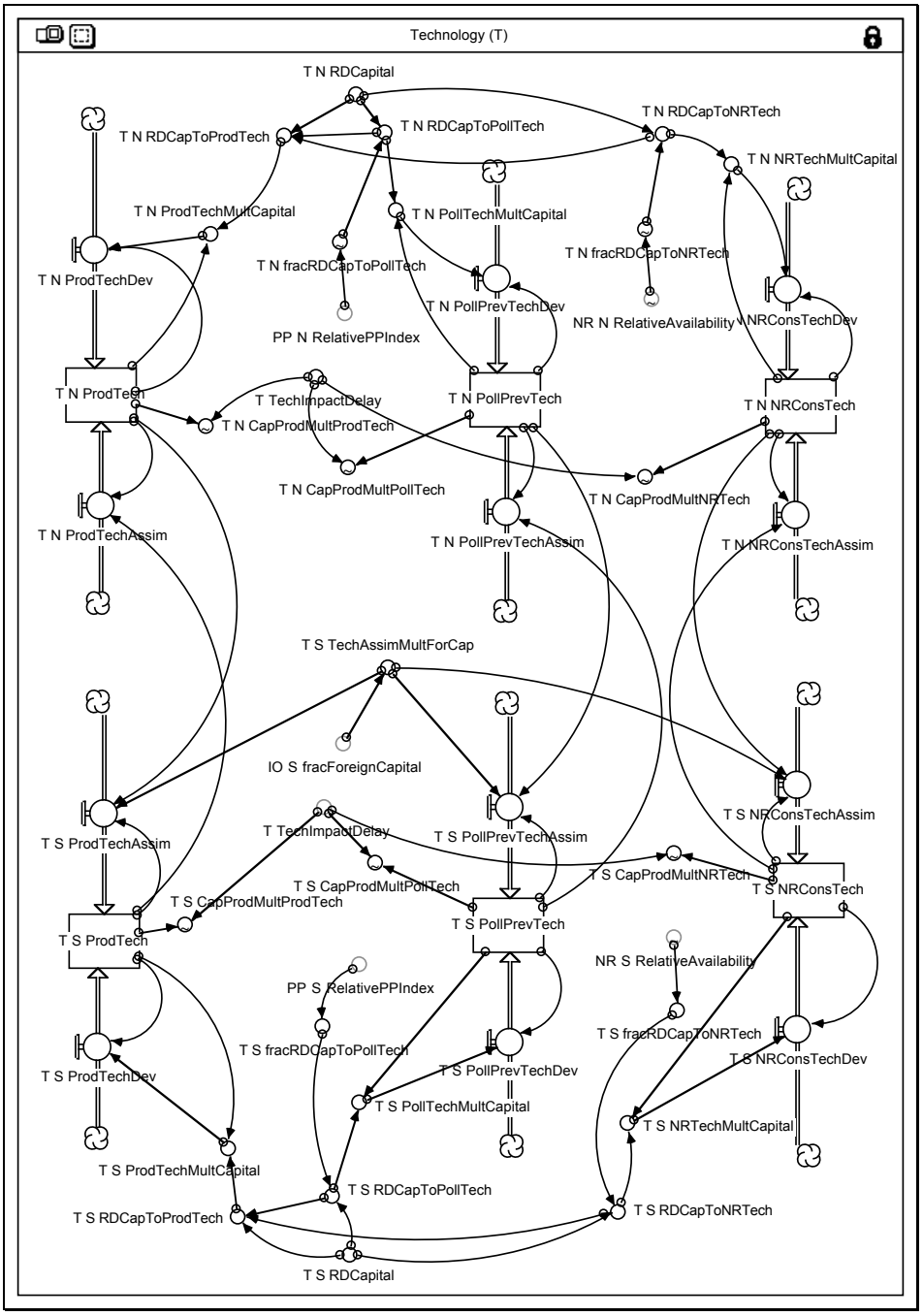

Figure 10: Stock-Flow Diagram of Technology Sector

Structural Issues:

Modeling approach to technology in this research differs from the one in WORLD3. In the first version of WORLD3, technology did not appear as a separate variable in the model. In the later versions of the model pollution

technology, land yield technology and resource consumption technology were explicitly included. However, production technology never appeared due to the assumption that capital deepening effect would offset the technological improvements. In this model, effect of capital deepening and production technology advance are separately modeled. Underlying idea is that, existence of a high-tech North may make it possible to increase productivity with technological improvements before capital deepening effect appears.

Quantification of the level of technology is a major problem. However, year 2000 is selected to be the index year and technology level of blocks is defined according to this index level.

ONGOING AND FURTHER RESEARCH

In the scope of this research, a world with two blocks is considered and effects of their interactions on global sustainability is formalized. In this manner dynamic hypothesis are put forth and model structures required to test these hypothesis are developed. In the current stage of the research, focus is on equation writing and parameter estimation. Following this stage model will be run in order to test the validity of the developed hypothesis and perform policy analysis.

REFERENCES

1. Aronson, E. The social animal. W. H. Freeman, San Francisco, c1976.
2. Chenery, H. B. Patterns of development, 1950-1970. Oxford University Press, London, 1975
3. Chudnovsky, D. “North-South Technology Transfer Revisited: Research Issues for The 1990s”, 1991
4. Cohen, J.E. How Many People Can The Earth Support? W.W. Norton & Company, 1995
5. Copeland, R.C., M.S. Taylor. “North-South Trade and the Environment”. The Quarterly Journal of Economics, Vol. 109, Issue 3 (Aug., 1994): 755-787
6. Daly, H. E. “Sustainable Development: Definitions, Principles, Policies”.
7. Daly, H. E. Ecological economics and the ecology of economics : essays in criticism. Northampton, c1999
8. Forrester, Jay W. World Dynamics. Wright-Allen Press, Massachusetts, 1971.
9. Lofdahl, C. L. Environmental Impacts of Globalization and Trade. The MIT Press, Massachusetts, 2002.
10. McAusland, C. “Voting for Pollution Policy: The Importance of Income Inequality and Openness to Trade”, 2002
11. Meadows, D. H., D. L. Meadows, J. Randers, and W. W. Behrens III. The Limits to Growth. Universe Books, New York, 1972.
12. Meadows, D. H., D. L. Meadows, and J. Randers. Dynamics of Growth in a Finite World. Wright-Allen Press, Massachusetts, 1974.
13. Meadows, D. L. Beyond The Limits. Chelsea Green Publishing, Vermont, 1992.

14. Myrdal, G. Economic theory and under-developed regions. Methuen, London, 1963
15. Myrdal, G. Asian drama : an inquiry into the poverty of nations. Allen Lane the Penguin Press, London,1968
16. Randers, J. “From Limits to Growth to Sustainable Development”. System Dynamics Review, Vol. 16, No:3, (Fall 2000): 213-224
17. Sterman, J. D. Business Dynamics: Systems Thinking and Modeling in a Complex World. McGraw-Hill, Boston, 2000.

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