THE DYNAMICS OF INDUSTRIAL TECHNOLOGICAL CAPABILITY IN INDONESIAN ECONOMIC DEVELOPMENT

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ABSTRACT:

This paper attempts to understand the structure underlining the weakness of the Indonesian economic development strategy in a systemic perspective. The explanation assumes the importance of industrial technological capability within the framework of the techno-economic structure. The results of a simulated model of techno-economic administration show the weakness of the industrial technological capability. This is a determinant factor of low industrial efficiency that brings about the current discontinuity in economic progress. On the basis of policy simulation, there are techno-economic policy initiatives needed to strengthen the future industrial technological capability. It implies that there is a need to shift from economic towards techno-economic policy orientations. Failure to confront this policy issue will make a new cycle of economic crisis possible.

Key words: *economy, industry, technology, innovation, R&D, system dynamics, policy*.

INTRODUCTION

Despite the successful maintenance of high economic growth, low inflation and political stability for more than three decades, the Indonesian economy was in a fragile condition against external shocks coming from the Asian economic turbulence. We argue that the crisis stemmed from the weakness of the techno-economic system. There are two symptoms of this weakness. *First*, while imported technology in the form of capital goods has been able to increase economic growth, it has created a heavy dependence on foreign technology suppliers. *Second*, the technology dependence has hampered and delayed domestic technological innovation based on local R&D efforts.

There are three basic assumptions that have guided this research: *first*, technology plays an important role in economic development; *second*, industrial technological capability is the key to competitiveness as well as the driver of economic growth, and; *third,* the process of building up technological capability is reflected by R&D efforts in enhancing industrial efficiency and productivity.

On the basis of above symptoms and assumptions, this research has constructed a model of interaction between the elements involved in the techno-economic system. The elements which constitute the system are as follows: *first*, the main elements of the technology component are: public R&D, industrial R&D, industrial efficiency, R&D partnership, and public R&D administration. *Second*, the main element of the economic component is the industrial sector, especially non-oil and gas industries *Third*, other elements are: the level of industrial technology capability planned by the government and the way the global environment influences the realisation of the goal. The system is depicted in **Figure 1**.

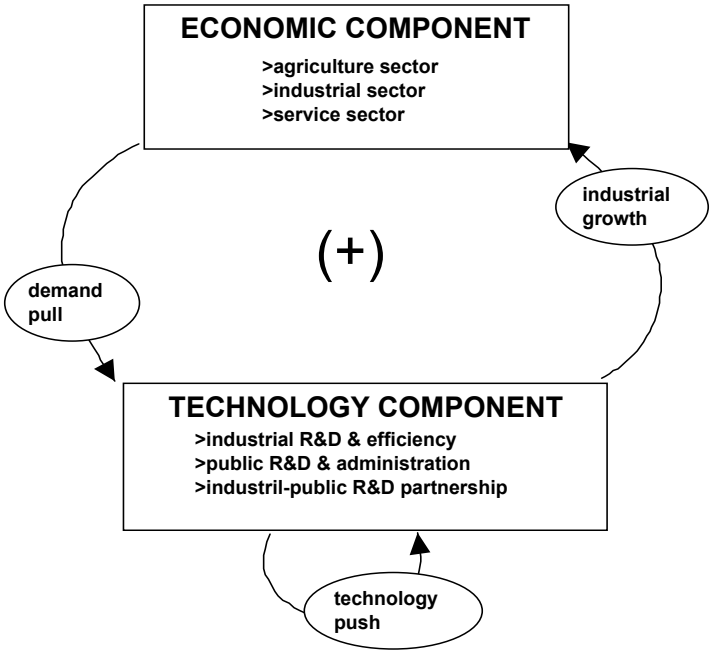


Figure 1: Techno-economic System

MODEL STRUCTURE

The Dynamics of Techno-Economic Administration

The model is developed from three relevant concepts. *First*, public administration in a systemic perspective as interaction among elements of policy, organisation and management within a given political circumstance. *Second*, the role of the learning organisation is important for creating a core of technological capability especially in industry. *Third*, the nature of techno-economy is the dynamic interaction between technology and the economy. A combination of those three concepts into an integrated view has produced a theoretical framework the so-called generic structure techno-economics learning. The system is an interaction between the economic and technology loop that is a workable process of generating technology invention and innovation, in order to achieve the desired level of technological capability. The positive feedback loop between the economy and technology components is a learning loop, where added value in the economy is pushed by accumulated experience in building up the technological capability. On the other hand, R&D efforts towards enhancing the technological capability are pulled by articulated demand in the economy. The system is depicted in **Figure 2.**

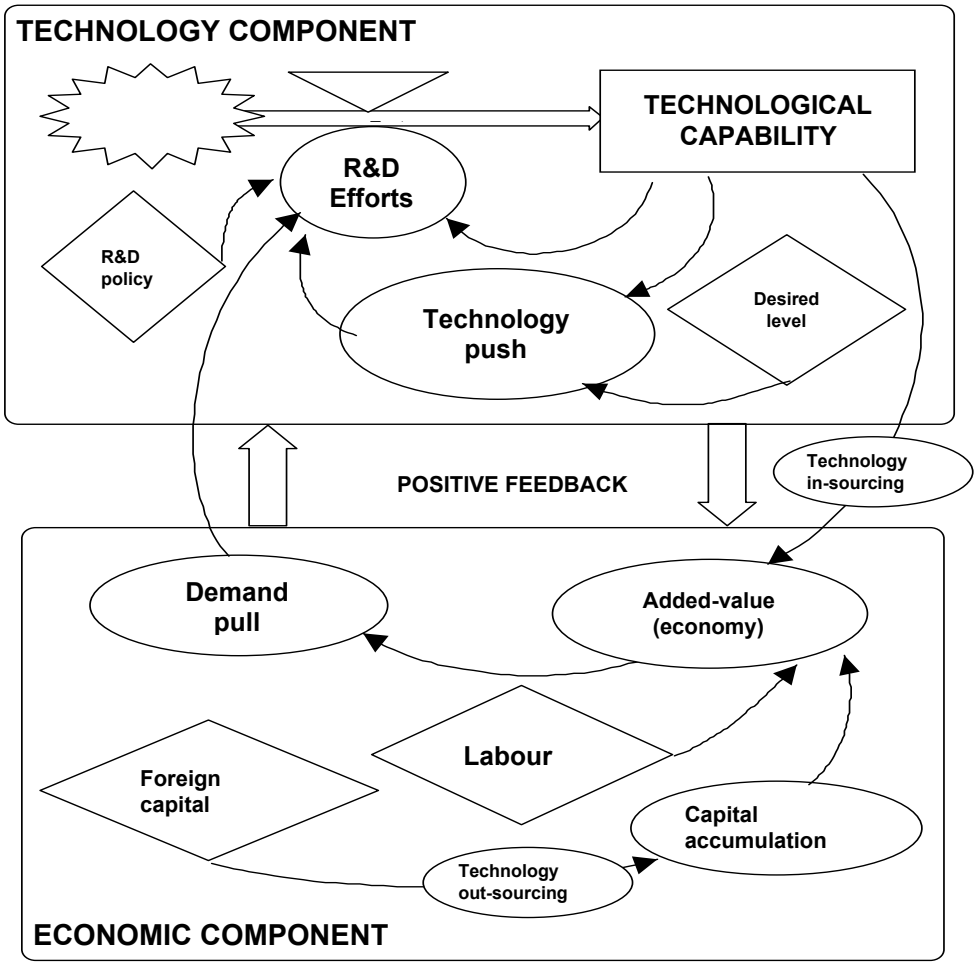


Figure 2: Generic Structure of Techno-economics Learning

On the basis of the above generic structure, the following reinforcing (R) and balancing (B) loops have been formulated: *first*, industrial R&D is an integral part of the positive feedback between economic and technology component. *Second*, industrial productivity in the economy is influenced by industrial R&D, on the other hand, industrial R&D is driven by industrial productivity in the economy (R3). *Third*, industrial productivity is also influenced by the dynamic of economic development, where the oil & gas industry-dependent economy affects the development of the non-oil & gas industry-based economy (B1, B2, and R1). *Fourth*, industrial R&D is also influenced by the dynamic of industrial efficiency, where the tendency towards technology importing leads to the dependency on imported technology that has resulted in hampering domestic industrial R&D (B3, B4, R2). *Fifth*, the policy on R&D partnership (R5, R6) between public sector (B5, R4) and industry will influence industrial R&D in the long run. *Sixth*, industrial and technology policies under managed market competition are the incentives for promotion of industrial R&D in enhancing efficiency based on technological innovation. See **Figure 3**.

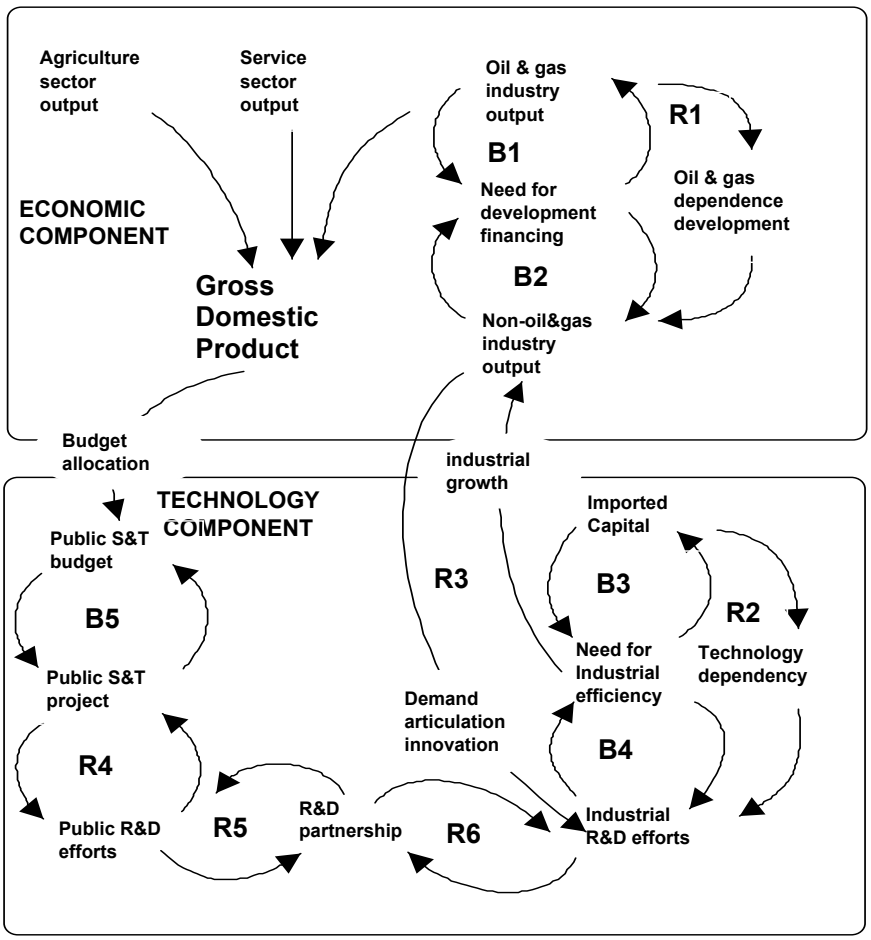


Figure 3: Dynamics of Techno-economic Administration

Total Dynamic Efficiency

The model of total dynamic efficiency (**TDE**) here is found in the process of developing the large-scale model of techno-economic administration, as discussed above. Total Dynamic efficiency is an integration of the efficiencies that are gained from input efficiency and process efficiency. The input efficiency is gained from the dynamics response of inputs against external change, with the aim at minimising inputs utilisation. The process efficiency is gained from the transformation of adjusted inputs into outputs, with the aim at maximising outputs. See **Figure 4.**

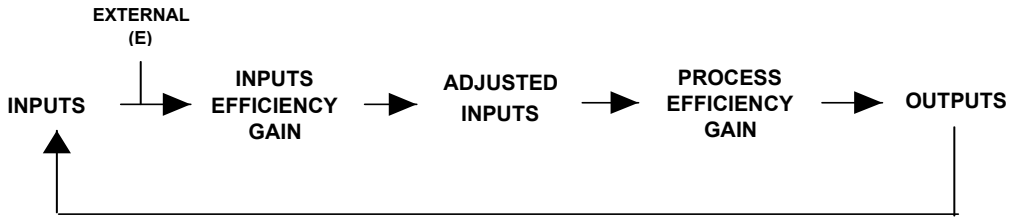


Figure 4: Total Dynamic Efficiency Model

SIMULATION RESULTS

Understanding Past Events

During the period 1969-1994, the mechanism of increasing industrial output in the economy was not pushed by industrial technological innovation based on R&D, nor did industrial R&D significantly increase industrial output. The pattern of industrial growth shifted from an oil and gas industry-dependent economy in the 1970s towards the non-oil and gas industry-based economy in the 1980s. Both sources of growth were heavily

dependent on imported capital and technology. Entering the 1990s, the excessive imported capital and technology went beyond the limits of market absorption causing diminishing returns in the economy. The tendency toward over-investment went to the non-productive sectors, mainly property, and this finally pushed Indonesia into a bubble economy which was susceptible to the financial turmoil in 1997.

The growth rate of public R&D expenditure between 1969-1994 was limited by the government development budget that was also determined by national income from the economic component. The utilisation of such a small public R&D expenditure was mostly directed to support the public research institutions that had no relationship with technological innovation in the industrial sector. The robust growth of the industrial sector since the mid 1980s has been accompanied by under-investment in research and innovation. The situation was aggravated by lack of market competition and heavy protection that have long caused the big industries to remain weak. Those industries were most adversely affected by the monetary crisis of mid 1997.

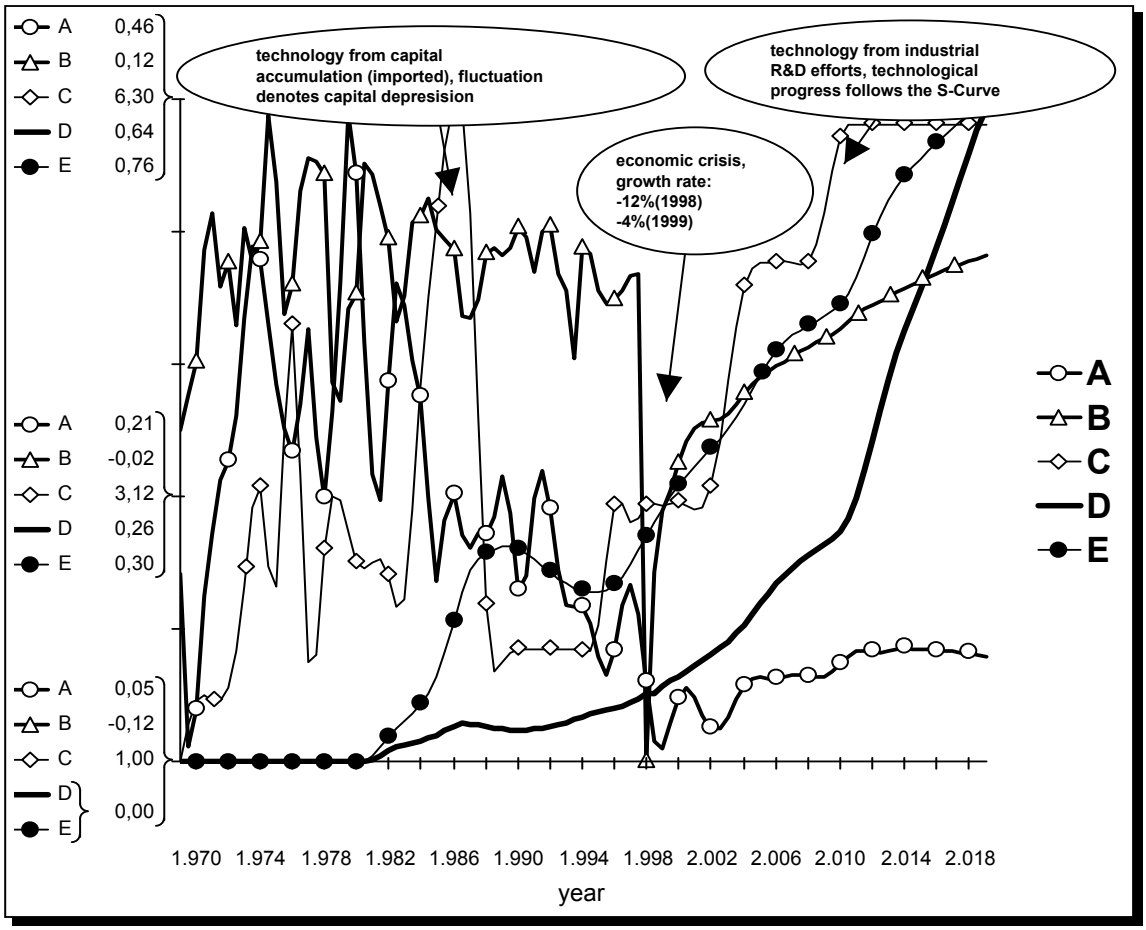
In 1995 the government launched the program of R&D partnership between the public and industrial sectors. The objective of the program was to encourage the participating industries in the partnership to actively spend on R&D for their future competitiveness. The program was unsuccessful because the partners failed to achieve a common R&D objective. There was also a tendency of rent seeking among participating partners by way of exploiting the program for personal interests. The program was halted in 1998 due to the economic crisis.

Awareness of Future Tendencies

Based on the computer simulation results, the industry is expected to have learnt from its past heavy dependence on foreign technology, where innovation based on R&D plays an important role for its long term-efficiency and productivity. In the period of 1999-2019 it is predicted that an increase in industrial output in the economy will start to be pushed by industrial technological capability. More specifically, the positive feedback between the components of economy and technology will be workable. Economic growth will start to be pushed by innovation based on R&D, and technological innovation will also start to be pulled by articulated demand in the economy. The following scenarios support these tendencies.

Economic growth will increase the fund allocation for industrial R&D expenditure. This kind of economic effect on industrial R&D expenditure will be subject to the following assumptions: i) the quick restoration of the technical capability which was destroyed during the prolonged economic crisis; ii) fairness in industrial competition in the economy by enacting the competition law, and; iii) a sound macro-economic and industrial policy in facing the global market in the twenty first century.

Technological innovation will be the source of economic growth. The contribution of industrial technological innovation to economic growth will increase significantly after the completion of economic, social and political reforms in 2008. At that time, technology-led industrialisation will start to be the driver of Indonesian economic growth based on the following assumptions: i) the quick restoration of the technical capability which was destroyed during the prolonged economic crisis; ii) during the crisis, the industrial sector is expected to take measures to impose technical efficiency such as industrial restructuring in order to survive in the time of economic turbulence, and; iii) starting from the year 2002 economic recovery will be on the track, and industry is expected to continue to enhance industrial efficiency through technical improvements and the utilisation of new production facilities. See **Figure 5**.



A: Rate growth of non-oil & gas Industries (%)
B: Rate growth of gross domestic production at constant price 1983 (%)
C: Index of industrial technological capability (1969=1)
D: Industrial R&D intensity (% of GDP)
E: Industrial R&D share to national R&D (%)

the normal scenario based on assumption of decreasing in investment growth by -50% in the start of economic crisis 1997.

Figure 5: Dynamic of Industrial R&D and Economy (1969-2019)

Learning from the economic crisis in 1998, which stemmed from the weakness of the techno-economic system, the following simulation results of intervention propose some options for managing the techno-economic system *First*, the promotion of investment to raise the accumulation of capital, labor and technical capability in large-scale industry. The capital and technology *out-sourcing* (imported from abroad) should be combined with the technology *in-sourcing,* (created by domestic industrial R&D) to accumulate technological capability. *Second*, the optimum utilisation of the existing, now grossly underutilized, industrial high-technology complexes in the form of technology incubators, for nurturing, strengthening and developing the competitive advantages of the promising small and medium-scale industries. *Third*, the revitalization of the national system of R&D institutions by regrouping the respective R&D institutions and public industries under a new umbrella of the Ministry of Science and Industrial Technology, for creating synergy between the national R&D institutions and the state-owned industry. *Fourth*, the continuation of the increasing and strengthening technology partnership between industry and public research institutions.

The above simulation results indicate that whatever policies will be undertaken by the Indonesian government to accelerate the domestic R&D, the intensity of industrial R&D will not reach the level of 1% of GDP in 2019 (approximately between 0.75-1% of GDP). It is because the initial level of industrial R&D at present (1998) is too low, around 0.035% of the GDP. Therefore, this research anticipates that Indonesia could be assumed to be a Newly Industrialized Country (NICs) only after the mid 2010s. In order to reach this level, the strategy of economic development based on the capital accumulation should be complemented with technology mastery through industrial R&D. It implies that a shifting policy orientation from economy towards techno-economy is needed for the future Indonesian economic development.

CONCLUDING REMARKS

Systemic thinking through the system dynamics method is an appropriate tool to analyze the complexity, dynamics, and the uncertainty of an object. This kind of method of analysis can explain the patterns of non-linearity inside a complex system. System dynamics method can be used as a tool of evaluation of past policy implementation (ex-post) and for future policy formulation (ex-ante).

Simulation results of past events show that: *first*, the Indonesian economic orientation has been strongly focused on the formation of capital accumulation in large-scale industries, which have gone beyond market absorption. Such a capital over-investment led to financial turmoil in 1997. *Second*, the weakness of the Indonesian economy is a severe lack of orientation on building-up technological capability, based on R&D in industries. Consequently, no creation of positive feedback emerged between economy and technology in the techno-economic system.

Simulation results of future scenarios indicate that a positive feedback between economy and technology is likely to accelerate after learning from the past events. For the future, capital and technology *out-sourcing* (imported from abroad) should be combined with technology *in-sourcing* (created by domestic industrial R&D) in order to accumulate technological capability. It implies a shift of policy orientation from economy towards techno-economy. Failure in nurturing awareness of technological capability and its consistent implementation in industries will make a new cycle of economic crisis in the future possible.

REFERENCES

Aminullah, E. (2000) *System Thinking: Policy Analysis Through Computer Simulation*, Jakarta: National Institute of Public Administration. (in Indonesian)

Aminullah, E. (1998) *Patterns and Tendencies of Research and Technology in Indonesia: The Dynamic Analysis of Techno-economic Administration*, Jakarta: University of Indonesia. (Unpublished Dissertation)

Aminullah, E. (1996) *Cooperative R&D in Developing the New technology: The Japanese Model of Industry - Academic Interaction*, Tokyo: Tokyo Institute of technology. (Research Report for Japanese Society for Promotion of Science)

Barlas, Y. (1996) "Formal Aspect of Model Validity and Validation in System Dynamics", *System Dynamics Review*, 12(3).

Dorothy, L. B. (1995) *Wellspring of Knowledge, Building and Sustaining the Sources of Innovation*, Boston: Harvard Business School Press.

Espejo, R. et.al. (1996) *Organization Transformation and Learning: A Cybernetics Approach to Management*, London: Macmillan.

Gayor, G. H. (ed) (1996) *Handbook of Technology Management*, New York: McGraw-Hill

Heijden, K. (1997) *Scenarios: The art of Strategic Conversation*, Chichester: John Wiley.

Hill, H. (1995) "Indonesia's Great Leap Forward? Technological development and Policy Issues" in *Bulletin of Indonesian Economic Studies*, 31(2).

Hill, H. (1996) *The Indonesian Economy Since 1966, South East Asia's Emerging Giant*, Cambridge: Cambridge University Press.

Kim, D. H. and Lannon, C. (1997) *Applying System Archetypes*, Cambridge: Pegasus.

Klein, A. K. (1998) *The Strategic Management of Intellectual Capital*, Boston: Butterworth-Heinemann.

Liebenstein, H. (1978) *General X- Efficiency Theory and Economic Development,* New york:Oxford University Press.

Marquadt, M. (1994) *The Global Learning Organization*, New York: Irwin.

McMaster, M. D. (1996) *The Intelligence Advantage, Organizing for Complexity*, Boston: Butter Worth.

Parsons, W. (1996) *Public Policy: An Introduction to the Theory and Practice of Policy Analysis*, Aldershot: Edwar Elgar..

Raimond, S.U. (ed) (1996) *The technology Link to Economic Development, Past lessons and Future Imperative*, New York: Academic Press.

Senge, P. M. et .al. (1994) *The Fifth Discipline Field Book*, Cambridge: Pegasus.

Senge, P. M. (1990) *The Fifth Discipline: the Art and Practice of the Learning Organization*, New York: Dobleday.

Tapscott, D. (1996) *The Digital Economy, Promise and Peril in the Age of Networked Intelligence*, New York: McGraw Hill.

World Bank (1993) *The East Asian Miracle, Economic Growth and Public Policy*, Oxford: Oxford University Press.

Yakushiji, T. (1984) "Reshuffling Firms for Technology? An Aggregate Time Series Analysis for B Klein's Dynamics Efficiency" in Aoki, M. (1984) *The Economic Analysis of Japanese Firm*, Amsterdam: North Holland.