New Frontiers in Regional Science: Asian Perspectives 52

Yoshiro Higano
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New Frontiers of Policy Evaluation in Regional Science

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New Frontiers in Regional Science: Asian Perspectives

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This series is a constellation of works by scholars in the field of regional science and in related disciplines specifically focusing on dynamism in Asia.

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New Frontiers of Policy Evaluation in Regional Science

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Preface

The Japan Section of the Regional Science Association International (JSRSAI) was founded in 1962 and has been active ever since. In 1991, it established a new award system to recognize the outstanding research achievements of its members and has been awarding the Encouragement Prize and the Best Paper Award since 1992.

The awards for encouragement are given to papers published by individuals or groups of researchers under the age of 37, which are budding papers on regional science that are judged to have sufficient potential for future development.

It is stipulated that the Best Paper Award is given to research papers that can be judged to be of great significance and contribution based on outstanding research achievements that have significantly contributed to the development of regional science. The evaluation of research achievements considers a wide range of academic results, such as new concepts in regional science as a basis for knowledge creation, excellent analytical methodologies, development, and improvement of databases, measurement methods, and systems, and new survey methods.

The Encouragement Award and the Best Paper Award are given to papers published in the JSRSAI-related journals *Studies in Regional Science* and *Papers in Regional Science* during the past 3 years before the awarding year. In principle, one Encouragement Award and one Best Paper Award will be given each year.

This book consists of two parts: theoretical research and empirical research in Policy Evaluation. The theoretical research section contains eight papers (Chaps. 1–9) on international trade, development of developing countries, organizational management, land development, disaster mitigation, environmental policy, and policy of the future society. The empirical studies section contains ten papers (Chaps. 10–19) on fiscal policy, real estate policy, food system, agricultural system, road policy, disaster prevention policy, environmental policy, and urban policy for Japan and China.

We hope that this book will contribute to the study of policy evaluation.

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Part I
Theoretical Research in Policy Evaluation

Chapter 1
Trade, Capital Accumulation, and Wage Differentials: A Dynamic Model of the Comparative Advantage Theory

Masaaki Abe

Abstract The decline in local economies has become more serious in recent years, and globalization has resulted in increasing regional disparities. The reason the gap has widened so much lies in the basic principle of a market economy: companies that operate in a market economy seek to maximize profits. There is no doubt that this pursuit of profit will be the engine of economic growth, but it is also true that continuing to increase profits raises various concerns. While it is true that the production structure of global companies is very efficient, social disparities will continue to grow.

In this paper, we construct an economic development model for two regions (south and north) and three sectors (agriculture, industry 1, and industry 2). We show that due to labor constraints in industrialized regions, each region specializes in the production of different goods only by increasing wages, and present a model showing the process that achieves endogenous equal development.

Initially, even if capital accumulation in the two industries is more advanced in the north than in the south, labor supply will be short in the north, and wages will rise in that region. The competitiveness of the north declines, and in industries where capital accumulation has been relatively slow in the north, the south can also develop. As a result, each region will specialize in one industry. However, this results in a wage gap between the north and south.

Keywords International trade · Regional disparities · Capital accumulation · Wage differentials

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1.1 Introduction

The decline in local economies has become more serious in recent years, and globalization has resulted in increasing regional disparities. According to the report "Reword Work, not Wealth" by Oxfam, an international non-governmental organization, "Last year saw the biggest increase in billionaires in history, one more every 2 days. This huge increase could have ended global extreme poverty seven times over. 82% of all wealth created in the last year went to the top 1%, and nothing went to the bottom 50%" (Oxfam 2018).

The reason the gap has widened so much lies in the basic principle of a market economy: companies that operate in a market economy seek to maximize profits. There is no doubt that this pursuit of profit will be the engine of economic growth, but it is also true that continuing to increase profits raises various concerns. If market competition develops on a global scale, a handful of winners will inevitably become huge global companies, and in the growth process, countless companies will go bankrupt or become affiliated companies. While it is true that the production structure of global companies is very efficient, social disparities will continue to grow.

Krugman (1981) presented the mechanism causing the gap to widen as a dynamic model of international trade theory. Krugman describes an economic model consisting of two regions (north and south), each with two segments, agriculture and industry, with the assumption that there is free trade in industrial goods and the sectors of both countries have economies of scale. In a long-term equilibrium, the model shows that the industrial output of one segment tends to expand while the other contracts, demonstrating the unequal development in the north and south.

Several papers based on the Krugman model were published later, illustrating the potential for equal development. Dutt (1986) built a model that introduced an arrow-type learning effect instead of economies of scale where the long-term equilibrium was stable depending on the model's parameter values and the industrial sectors of both countries developed to a certain scale. However, in the main case, as in the Krugman model, the long-term equilibrium is unstable and results in unequal development of the two countries.

Kubo (1993, 1994) uses the Krugman model to show that when the industrial products produced in the two countries are different and are intermediate goods in other countries, equal development is possible. Kawano (1999) did not assume that the north and south would specialize in the production of different goods, but instead started with a concentration of capital in one area and then proceeded with technological progress in the agricultural sector; this specialization is derived endogenously.

In this paper, we construct an economic development model for two regions (south and north) and three sectors (agriculture, industry 1, and industry 2). We show that due to labor constraints in industrialized regions, each region specializes in the production of different goods only by increasing wages, and present a model showing the process that achieves endogenous equal development.

The idea of two industries is easy to understand by considering the computer industry and clothing industry. Initially, even if capital accumulation in the two industries is more advanced in the north than in the south, labor supply will be short in the north, and wages will rise in that region. The competitiveness of the north declines, and in industries where capital accumulation has been relatively slow in the north, the south can also develop. As a result, each region will specialize in one industry. However, this results in a wage gap between the north and south.

1.2 The Dynamic Model

This economic model has two regions, north (N) and south (S). Both regions have three industries, an agricultural sector and two industrial sectors that use the same technology. The agricultural sector uses a technology with constant returns to scale, with labor as the only factor of production.

The industrial sectors include both labor and capital as factors of production, using a technology with increasing returns to scale. It is assumed that the industrial goods (M^1, M^2) and agricultural products (A) are freely traded between the two regions. Therefore, the price of each good is the same in both regions. Since agricultural products are produced using only labor, units can be selected so that one unit of labor produces one unit of agricultural products. The prices of the industrial products are measured in terms of agricultural products, P^1 and P^2.

We assume that the labor force (L_{N}, L_{S}) in each region is equal at $\overline{L}$:

$$L_{\mathrm{N}} = L_{\mathrm{S}} = \overline{L} \tag{1.1}$$

The industrial sector uses labor (L) and capital (K) as production factors, and its production uses a fixed coefficient Leontief-type production function. It is assumed that the production technologies in both countries are the same, but due to economies of scale, the capital coefficient (c) and labor coefficient (v) decrease as the amount of capital increases.

Then, the coefficients given below are for the two industrial products,

$$c_j^i = c\left(K_j^i\right),\quad v_j^i = c\left(K_j^i\right) \quad (i = 1, 2 : j = N, S) \tag{1.2}$$

and satisfy the following properties for economies of scale:

$$c'(K) < 0, \quad v'(K) < 0 \tag{1.3}$$

In the initial state, we assume that the level of capital accumulation is lower than the labor force and that labor is not a constraint on the output of industrial goods.

Assuming that the two industrial products (M^1, M^2) are produced efficiently, then the outputs in both regions are determined as follows:

$$M_j^i = \frac{K_j^i}{c\left(K_j^i\right)} \quad (i = 1, 2 : j = N, S) \tag{1.4}$$

Given the output, the total labor requirement in the two industrial sectors of both regions is given by $v_N^1 M_N^1,\ \ v_N^2 M_N^2$ and $v_S^1 M_S^1,\ \ v_S^2 M_S^2$.

In the agricultural sector, one unit of labor produces one unit of agricultural product; therefore, the agricultural outputs (A) are determined as follows:

$$A_j = \overline{L} - v_j^1 M_j^1 - v_j^2 M_j^2 \quad (j = N, S) \tag{1.5}$$

In the economy formulated above, there is an upper limit to expanding production due to labor restrictions in the industrial sector. As the accumulation of capital in the industrial sector progresses, labor is absorbed into the industrial sector, but once all the labor has been absorbed, it is impossible to expand production in the industrial sector. The constraint formula for this labor force is given below:

$$v\left(K_j^1\right)\frac{K_j^1}{c\left(K_j^1\right)} + v\left(K_j^2\right)\frac{K_j^2}{c\left(K_j^2\right)} = \overline{L} \quad (j = N, S) \tag{1.6}$$

Next, the profit rate of industrial goods (ρ) is calculated. If there is no full specialization in the industrial sector, the wage rate measured for agricultural products will be one. Then, assuming that the prices of industrial goods are P^1 and P^2, the profit rate per unit of capital is given by dividing gross profit by the capital amount as follows:

$$\rho_j^i = \frac{P^i - v_j^i}{c_j^i} \quad (i = 1, 2 : j = N, S) \tag{1.7}$$

Here, since the capital coefficient (c) and labor coefficient (v) are functions of capital stock (K), Eq. (1.7) can be rewritten as follows:

$$\rho_j^i = \rho\left(P^i, K_j^i\right) \quad (i = 1, 2 : j = N, S) \tag{1.8}$$

The profit rate property is $\partial\rho/\partial P > 0$, $\partial\rho/\partial K > 0$ according to Eqs. (1.3) and (1.7). The second property is due to economies of scale.

Assume that all wage income is consumed and all profit income is saved and invested in the local area. Therefore, the capital accumulation function is as follows:

$$\frac{\dot{K}_j^i}{K_j^i} = \rho_j^i \quad (i = 1, 2 : j = N, S) \tag{1.9}$$

Since free trade is assumed for industrial goods, the price of industrial goods is determined by the balance between supply and demand. Assuming that a certain percentage of wage income (μ^1, μ^2) is allocated to the purchase of industrial goods 1 and 2 in each region, the supply-demand equation for industrial goods is as follows ($\mu^1 + \mu^2 < 1$):

$$P^i \left(M_{\mathrm{N}}^i + M_{\mathrm{S}}^i \right) = \mu^i \left(L_{\mathrm{N}} + L_{\mathrm{S}} \right) = 2\mu^i \overline{L} \quad (i = 1, 2) \tag{1.10}$$

The supply-demand equilibrium equation (1.10) for industrial goods can then be rewritten as follows:

$$P^i = \frac{2\mu^i \overline{L}}{\frac{K_{\mathrm{N}}^i}{c\left(K_{\mathrm{N}}^i\right)} + \frac{K_{\mathrm{S}}^i}{c\left(K_{\mathrm{S}}^i\right)}} = P^i \left(K_{\mathrm{N}}^i, K_{\mathrm{S}}^i \right) \quad (i = 1, 2) \tag{1.11}$$

Based on the simple differentiation and assumptions so far, the following holds for each of the industrial goods (1 and 2):

$$\frac{\partial P^i}{\partial K_j^i} < 0 \quad (i = 1, 2 : j = N, S) \tag{1.12}$$

That is, the capital accumulation in each industrial sector lowers the price of each industrial product through increased supply.

The dynamic model of two regions and two industrial goods can be summarized in the following formula:

$$\begin{aligned} \frac{\dot{K}_{\mathrm{N}}^i}{K_{\mathrm{N}}^i} &= \rho\left(P^i, K_{\mathrm{N}}^i\right) = g_{\mathrm{N}}^i\left(K_{\mathrm{N}}^i, K_{\mathrm{S}}^i\right) \\ \frac{\dot{K}_{\mathrm{S}}^i}{K_{\mathrm{S}}^i} &= \rho\left(P^i, K_{\mathrm{S}}^i\right) = g_{\mathrm{S}}^i\left(K_{\mathrm{S}}^i, K_{\mathrm{N}}^i\right) \end{aligned} \quad (i = 1, 2) \tag{1.13}$$

The following properties are derived for the functions g_{N} and g_{S}. This property is equal in industrial goods 1 and 2 due to the symmetry of the model:

$$\begin{aligned} \frac{\partial g_{\mathrm{N}}}{\partial K_{\mathrm{S}}} &= \frac{\partial \rho}{\partial P} \cdot \frac{\partial P}{\partial K_{\mathrm{S}}} < 0 \\ \frac{\partial g_{\mathrm{S}}}{\partial K_{\mathrm{N}}} &= \frac{\partial \rho}{\partial P} \cdot \frac{\partial P}{\partial K_{\mathrm{N}}} < 0 \\ \frac{\partial g_{\mathrm{N}}}{\partial K_{\mathrm{N}}} &= \frac{\partial \rho}{\partial P} \cdot \frac{\partial P}{\partial K_{\mathrm{N}}} + \frac{\partial \rho}{\partial K_{\mathrm{N}}} \\ \frac{\partial g_{\mathrm{S}}}{\partial K_{\mathrm{S}}} &= \frac{\partial \rho}{\partial P} \cdot \frac{\partial P}{\partial K_{\mathrm{S}}} + \frac{\partial \rho}{\partial K_{\mathrm{S}}} \end{aligned} \tag{1.14}$$

From these two equations, it can be seen that capital accumulation in one industrial sector lowers the price of industrial goods, thereby lowering the profit rate (capital accumulation rate) of the industrial sector in the other region. However, in the two equations below, it can be seen that capital accumulation in the local industrial sector has a direct positive effect on the rate of return arising from economies of scale, in addition to a negative effect through price. Therefore, the net effect on the profit rate (capital accumulation rate) is unknown. For the sake of simplicity, it is assumed that the absolute value of the effect of price exceeds that of the effect of scale; this assumption has no intrinsic effect on the model conclusion:

$$\frac{\partial g_j}{\partial K_j} < 0 \quad (j = N, S) \tag{1.15}$$

The long-term equilibrium of this model is given by $\dot{K}_j = 0 \ \ (j = N, S)$. This is equivalent to $g_{\mathrm{N}}(K_{\mathrm{N}}, K_{\mathrm{S}}) = 0$, $g_{\mathrm{S}}(K_{\mathrm{S}}, K_{\mathrm{N}}) = 0$. From Eqs. (1.14) and (1.15), the following properties are satisfied on the curve $g_{\mathrm{N}} = 0$:

$$\frac{\mathrm{d}K_{\mathrm{N}}}{\mathrm{d}K_{\mathrm{S}}} = -\frac{\frac{\partial g_{\mathrm{N}}}{\partial K_{\mathrm{S}}}}{\frac{\partial g_{\mathrm{N}}}{\partial K_{\mathrm{N}}}} < 0 \tag{1.16}$$

In other words, on the $K_{\mathrm{S}} \cdot K_{\mathrm{N}}$ plane, the $\dot{K}_{\mathrm{N}} = 0$ curve goes down to the right, with $\dot{K}_{\mathrm{N}} < 0$ on the right side of the curve and $\dot{K}_{\mathrm{N}} > 0$ on the left side of the curve.

On the other hand, the following properties are satisfied on the curve $g_{\mathrm{S}} = 0$. This curve also goes down to the right, with $\dot{K}_{\mathrm{S}} < 0$ on the right side of the curve and $\dot{K}_{\mathrm{S}} > 0$ on the left side of the curve:

$$\frac{\mathrm{d}K_{\mathrm{N}}}{\mathrm{d}K_{\mathrm{S}}} = -\frac{\frac{\partial g_{\mathrm{S}}}{\partial K_{\mathrm{S}}}}{\frac{\partial g_{\mathrm{S}}}{\partial K_{\mathrm{N}}}} < 0 \tag{1.17}$$

Next, the relative slope of the $\dot{K}_{\mathrm{N}} = 0$ curve ($g_{\mathrm{N}} = 0$ curve) and the $\dot{K}_{\mathrm{S}} = 0$ curve ($g_{\mathrm{S}} = 0$ curve) is confirmed.

According to Eqs. (1.14) and (1.15), which show the properties of the functions g_{N} and g_{S}, the capital accumulation in one region reduces the profit rate in both regions, but it can be seen that the rate of decline in the profit rate of its own region is smaller than in other regions because of economies of scale. Therefore, the following equation holds:

$$\left|\frac{\partial g_{\mathrm{N}}}{\partial K_{\mathrm{N}}}\right| < \left|\frac{\partial g_{\mathrm{N}}}{\partial K_{\mathrm{S}}}\right|, \quad \left|\frac{\partial g_{\mathrm{S}}}{\partial K_{\mathrm{S}}}\right| < \left|\frac{\partial g_{\mathrm{S}}}{\partial K_{\mathrm{N}}}\right| \tag{1.18}$$

According to Eqs. (1.16), (1.17), and (1.18), the slope of the $\dot{K}_{\mathrm{N}} = 0$ curve is steeper than the slope of the $\dot{K}_{\mathrm{S}} = 0$ curve. As a result, the phase diagram of this model can be drawn for industrial goods 1 and 2, as shown in Fig. 1.1:

1.3 The Growth Pathway

Using the models assembled in the previous section, we examine the long-term growth paths of industry 1 and industry 2 in both the north and south regions. When analyzing this model's long-term equilibrium, two cases may be considered. The

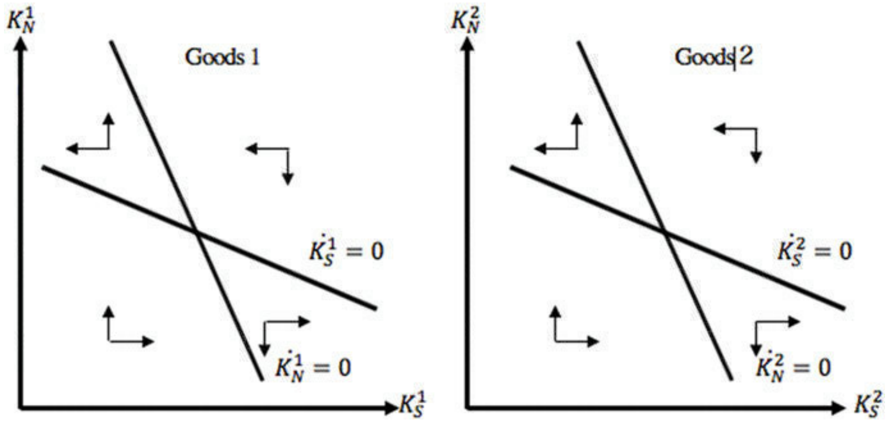

Fig. 1.1 Phase diagrams of industrial goods 1 and 2

first case is that, at the initial stage, each region has a capital stock of one industrial good superior to the other region. The second case is that, at the initial stage, one region is superior to the other region in its capital stock of both industrial goods.

Therefore, in Sect. 1.3.1, we look at Case 1 as the growth path when the north region has an industrial good 1 that is slightly superior to that of the south region, and the south region has an industrial good 2 that is somewhat superior to that in the north region. Then, in Sect. 1.3.2, as Case 2, we analyze the growth path when the capital accumulation in the north at the initial stage is slightly greater compared to that of the south in both industrial goods 1 and 2.

1.3.1 Analysis when each Region Is Superior in One Good

Here, at the initial stage, we examine the growth path when the north has an industrial good 1, which is slightly superior to that of the south, and the south has an industrial good 2, which is somewhat superior to that in the north. First, we look at the process of capital accumulation in industrial good 1 in both the north and south regions.

As shown in the phase diagram of industrial good 1 in Fig. 1.2, at the initial stage, capital accumulation in the north started at a little higher level than in the south. As the capital accumulation progressed in both regions, the difference in the levels of capital accumulation gradually widens, and in the long term, the capital of industrial good 1 will be concentrated in the north.

Next, we look at the process of capital accumulation in industrial good 2 in the north and south. Here, in the phase diagram of industrial good 2 in Fig. 1.2, the process is completely opposite that of industrial good 1, and in the long term, the capital of industrial good 2 will be concentrated in the south.

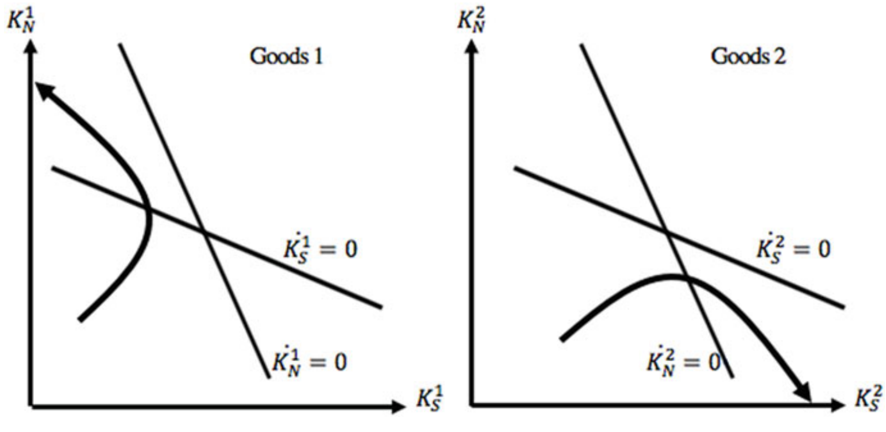

Fig. 1.2 Growth paths of industrial goods 1 and 2 (Case 1)

This case shows that unequal development occurs in each good, consistent with Krugman's analysis. In the long term, each region specializes in its own goods, and both regions develop superior goods.

1.3.2 Analysis when One Region Is Superior in both Goods

In this case, we analyze the growth path when the capital accumulation in the north at the initial stage is slightly greater than the south's in both industrial goods 1 and 2.

At first, the capital accumulation process shown in the phase diagram of good 1 shown in Fig. 1.2 in Sect. 1.3.1 occurs in both goods, and both industries develop in the north. However, when industry 1 and industry 2 continue to grow together in the north, all the labor force existing in the north will eventually be absorbed as a production factor of industrial goods 1 and 2, and no further growth will be possible due to labor constraints (Oxfam 2018).

Figure 1.3 shows this labor constraint using the production volumes of two industrial goods $\left(M_{\mathrm{N}}^1, M_{\mathrm{N}}^2\right)$ in the north.

When the north's economy is on the labor constraint line in Fig. 1.3, both industries have stopped growing because of this constraint, but profits are positive. It is assumed here that this profit cannot be used for capital accumulation and is therefore allocated to higher wages for northern workers. Let $w_{\mathrm{N}} (w_{\mathrm{N}} > 1)$ be the wage rate in the north that begins rising, and the wage rate increase is expressed by the following equation:

$$\frac{\dot{w_{\mathrm{N}}}}{w_{\mathrm{N}}} = \rho_{\mathrm{N}}^1 + \rho_{\mathrm{N}}^2 \quad \text{if} \;\; v_{\mathrm{N}}^1 M_{\mathrm{N}}^1 + v_{\mathrm{N}}^2 M_{\mathrm{N}}^2 = \overline{L} \;\; \text{and} \;\; \rho_{\mathrm{N}}^i \geq 0 \tag{1.19}$$

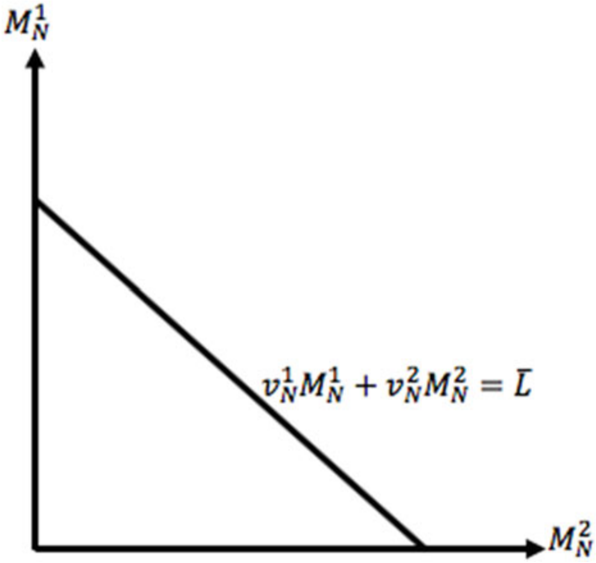

Fig. 1.3 The labor constraint line in the north

As growth is limited by labor shortages, the assumption of increasing wages to acquire workers seems realistic. However, this wage increase only occurs in the north, and the wage rate in the south remains at $w_S = 1$. Here, we do not consider the transfer of labor between regions. Due to the worsening trade terms caused by the continued increase in wages, when the profit rate of either industry becomes negative, labor shifts from industries with negative profits to industries with positive profits, and the wage increases stop.

We find the supply-demand equation and profit function after the start of the wage increase in the north. First, the supply-demand equation is as follows:

$$P^i \left(M_N^i + M_S^i\right) = \mu^i \left(w_N L_N + L_S\right) = \mu^i \left(1 + w_N\right) \overline{L} \tag{1.20}$$

The following equation is obtained by modifying Eq. (1.20):

$$P^i = \frac{\mu^i (1+w_N)\overline{L}}{M_N^i + M_S^i} \tag{1.21}$$

Here, it can be seen from a simple differentiation that an increase in the wage rate in the north will raise the prices of industrial goods 1 and 2:

$$\frac{\partial P^i}{\partial w_N} > 0 \tag{1.22}$$

Then, the north and south profit functions are as follows:

$$\rho_{\mathrm{N}}^{i} = \frac{P^{i} - v_{\mathrm{N}}^{i} w_{\mathrm{N}}}{c_{\mathrm{N}}^{i}}, \quad \rho_{\mathrm{S}}^{i} = \frac{P^{i} - v_{\mathrm{S}}^{i}}{c_{\mathrm{S}}^{i}} \tag{1.23}$$

From the above, the profit function for industrial goods 1 and 2 in the north and south can be defined as follows:

$$\begin{aligned} &\rho_{\mathrm{N}}^{1}\left(P^{1}, K_{\mathrm{N}}^{1}, w_{\mathrm{N}}\right) = h_{\mathrm{N}}^{1}\left(K_{\mathrm{N}}^{1}, K_{\mathrm{S}}^{1}, w_{\mathrm{N}}\right) \\ &\rho_{\mathrm{S}}^{1}\left(P^{1}, K_{\mathrm{S}}^{1}\right) = h_{\mathrm{S}}^{1}\left(K_{\mathrm{N}}^{1}, K_{\mathrm{S}}^{1}, w_{\mathrm{N}}\right) \\ &\rho_{\mathrm{N}}^{2}\left(P^{2}, K_{\mathrm{N}}^{2}, w_{\mathrm{N}}\right) = h_{\mathrm{N}}^{2}\left(K_{\mathrm{N}}^{2}, K_{\mathrm{S}}^{2}, w_{\mathrm{N}}\right) \\ &\rho_{\mathrm{S}}^{2}\left(P^{2}, K_{\mathrm{S}}^{2}\right) = h_{\mathrm{S}}^{2}\left(K_{\mathrm{N}}^{2}, K_{\mathrm{S}}^{2}, w_{\mathrm{N}}\right) \end{aligned} \tag{1.24}$$

The properties of the functions h_{N} and h_{S} are the same as the properties of g_{N} and g_{S} shown in Eq. (1.14) for K_{N} and K_{S}, but we have the following properties for the new element w_{N}:

$$\begin{aligned} \frac{\partial h_{\mathrm{N}}}{\partial w_{\mathrm{N}}} &= \frac{\partial \rho}{\partial P}\frac{\partial P}{\partial w_{\mathrm{N}}} + \frac{\partial \rho}{\partial w_{\mathrm{N}}} \\ \frac{\partial h_{\mathrm{S}}}{\partial w_{\mathrm{N}}} &= \frac{\partial \rho}{\partial P}\frac{\partial P}{\partial w_{\mathrm{N}}} > 0 \end{aligned} \tag{1.25}$$

In other words, an increase in wages in the north raises the profit rates of industries 1 and 2 in the south by raising the prices of both industrial goods. On the other hand, the effect of rising wages in the north on the north's industrial profits cannot be determined because the increase has both a positive effect (increase in prices) and a negative effect (increase in wages). However, to make the results of the analysis more certain, it is assumed, as a favorable condition for the north, that increasing wages in the north will increase the profit rate in the north. Under this assumption, we can show that one industry can be developed in the south in the long run:

$$\frac{\partial h_{\mathrm{N}}}{\partial w_{\mathrm{N}}} > 0 \tag{1.26}$$

From the above formulation, the phase diagram shown in Fig. 1.1 in Sect. 1.2 changes as shown in Fig. 1.4, due to the increase in wages in the north. That is, the zero-profit curve ($\dot{K}_{\mathrm{N}} = 0$ curve, $\dot{K}_{\mathrm{S}} = 0$ curve) moves to the upper right. However, as can be seen from Eq. (1.25), since $\partial h_{\mathrm{N}}/\partial w_{\mathrm{N}} < \partial h_{\mathrm{S}}/\partial w_{\mathrm{N}}$, the $\dot{K}_{\mathrm{S}} = 0$ curve moves faster than the $\dot{K}_{\mathrm{N}} = 0$ curve.

As described above, it is possible to see a growth path in the case where capital accumulation in the north at the initial stage is slightly advanced compared to the south in both industrial goods 1 and 2.

First, assuming that the capital accumulation of industrial good 1 in the north is delayed compared to industrial good 2 in the north, then the growth path of industrial good 1 is examined in Fig. 1.5.

In the first phase, the north's gap with the south will gradually increase, accumulating capital for industrial good 1 until it encounters labor constraints. Then,

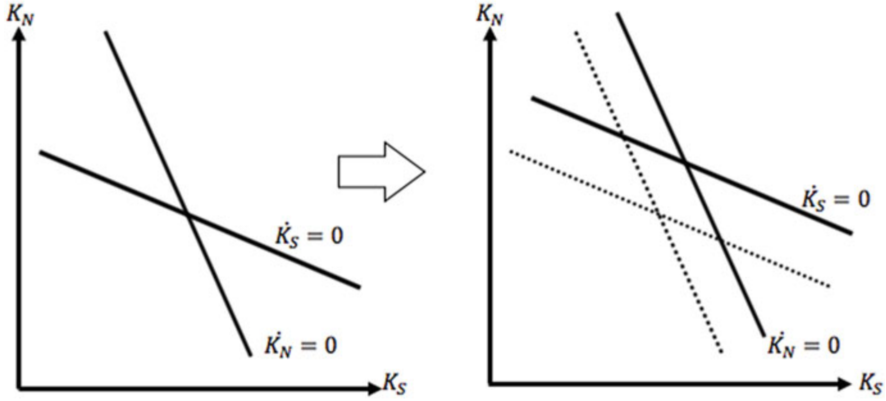

Fig. 1.4 Changes in the phase diagram due to rising wages in the north

the wage increase in the north begins, and the zero-profit curve starts to move to the upper right.

In the second phase, capital in the north will remain unchanged while capital in the south will decline as profits are negative. However, the industrial profit in the south enters positive territory, and the south begins to accumulate capital.

Then, in the third phase, as the zero-profit curve moves to the upper right, the south accumulates capital and catches up with the north's zero-profit curve. Here, the industrial profits in the north enter negative territory, the capital of industrial good 1 in the north begins to decrease, and capital accumulation in the south proceeds smoothly. In this third phase, labor is released due to a decrease in the capital accumulation of industrial good 1 in the north, and wage growth in the north will halt.

The released labor force moves to the production of industrial good 2, which was superior to industrial good 1 in the north. Then, since the wage increase has stopped, the movement of the zero-profit curve in the phase diagram also stops.

As described above, the capital accumulation of industrial good 1 that the north advanced first worsened the terms of trade in the north and improved the terms of trade in the south due to the increase in wages in the north as a result of labor constraints. Consequently, it eventually develops in the south.

On the other hand, looking at the growth path of industrial good 2, the profits were positive even in the third period, because they were superior to industrial good 1 in the north at the initial stage. The movement of the zero-profit curve also stops. Then, since labor moves from industry 1, the capital accumulation of industrial good 2 in the north resumes (Fig. 1.6).

The analysis above shows that even if the two goods preceded capital accumulation in the north compared to the south, each region would eventually grow in one good. However, even in this case, there is a difference in wages between north and south.

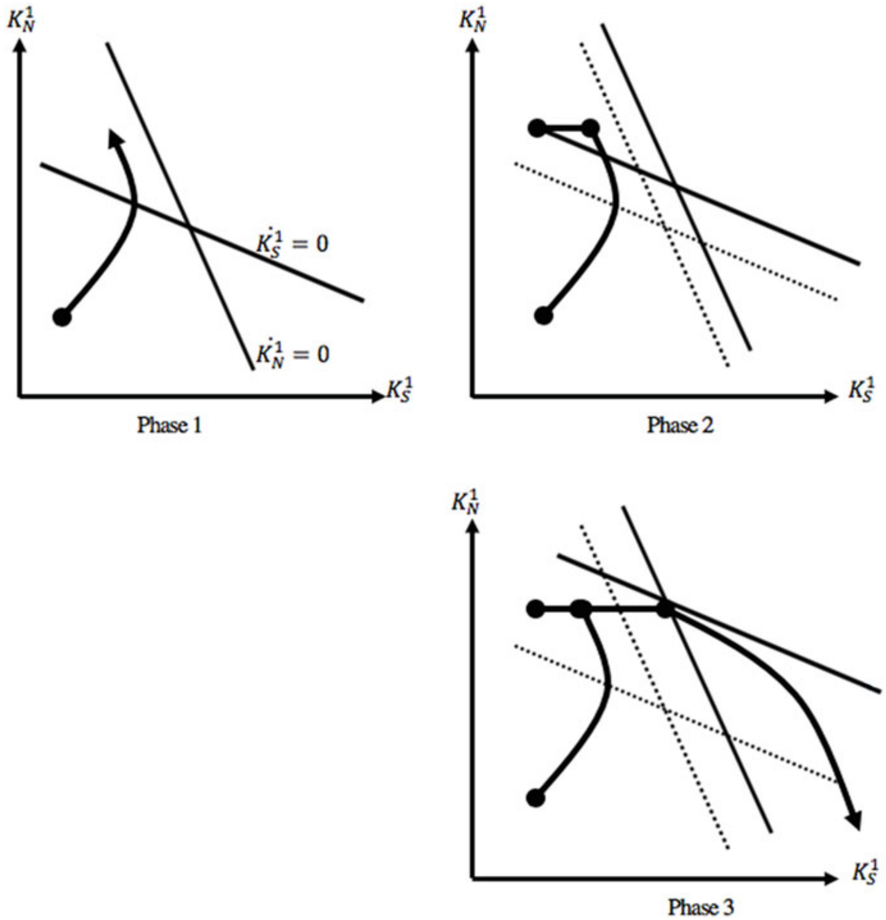

Fig. 1.5 Growth path of industrial good 1 in the north and south

Next, we find the final northern wage rate (w_N). In the third period, when the capital accumulation level is located at the intersection of the $\rho_N^1 = 0$ curve and the $\rho_S^1 = 0$ curve, wage increases in the north stop.

From Eqs. (1.21) and (1.23), the equations of the respective curves can be shown as follows:

$$\begin{aligned} &\rho_N^1 = 0 \ \text{curve} : \frac{\mu^1(1+w)\overline{L}}{K_N^1/c_N^1 + K_S^1/c_S^1} = v_N^1 w \\ &\rho_S^1 = 0 \ \text{curve} : \frac{\mu^1(1+w)\overline{L}}{K_N^1/c_N^1 + K_S^1/c_S^1} = v_S^1 \end{aligned} \tag{1.27}$$

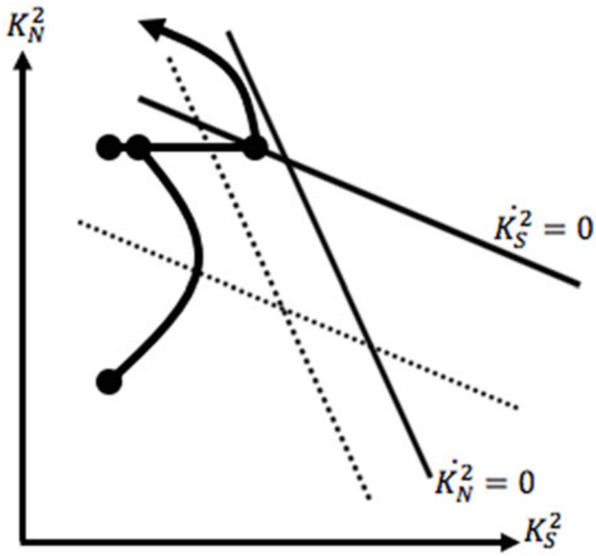

Fig. 1.6 Growth path of industrial good 2 in the north and south

From Eq. (1.27), the relative wage (w_N) is obtained as follows:

$$w_N = \frac{v(K_S^1)}{v(K_N^1)} \tag{1.28}$$

That is, the relative wage is equal to the labor productivity ratio of the two regions at the intersection of the $\rho_N^1 = 0$ curve and the $\rho_S^1 = 0$ curve in the third period.

1.4 Conclusion

In this paper, we introduce to Krugman's uneven development model between the north and south the assumption that there are two types of industrial goods and propose a model in which the north and south produce one good each and achieve equal development.

However, when at the beginning, the north accumulates capital earlier than the south in both goods, equal development was achieved in terms of capital accumulation, but there was a wage gap between north and south. This paper shows the mechanism that creates this north-south wage gap.

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Chapter 2
Ex Post Risk Management of Environmental Contamination of Municipal Water

Chisato Asahi and Kiyoko Hagihara

Abstract This chapter investigates the possibility of ex-post risk management for local governments facing the risk of tap water pollution; this is still required to deal with the difficulty of prediction and urgency, even after the ex-ante risk management method has been introduced into the tap water quality management system. In Sect. 2.1, we categorize three ex-post risk management methods. In Sect. 2.2, we analyse the efficiency of risk sharing using insurance contracts. Then, based on the implications of the analysis in Sect. 2.2, the applicability of insurance risk sharing in tap water pollution is discussed in Sect. 2.3.

By investigating the applicability of insurance by the agency theory, we showed that the subsidy-based risk sharing system is promising as an ex-post management system of water pollution risk. However, distortions in resource allocation due to the subsidy system are not negligible problems; it is necessary that a comprehensive comparison of the applicability of an ordinary private insurance system is conducted, which can better enjoy the efficiency of the market mechanism. The benefits of creating an integrated insurance system for comprehensive environmental risks including air pollution or soil pollution is discussed, which will bring benefits of risk pooling and lower insurance premium in the case that the insurance applicability fails because the water pollution risk from tap water alone has no marketability for small-sized businesses.

Keywords Tap water pollution · Risk management · Asymmetric information · Agency theory · Insurance

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Risk management regarding the safety of tap water in Japan is stipulated by the water supply law as follows: (1) compliance with water quality standards and implementation of water quality inspections, (2) compliance with structural and material standards of supply facilities, (3) health checkups of water purification workers, and (4) hygiene measures. The tap water quality standard had been established mainly for substances with a clear causal relationship to health damages, but the revision of the tap water quality standard in 1993 introduced the concept of risk management and subsequently built the basic system of water quality risk management (Asami 2016). In the revision, there are three features. First, with reference to the WHO Guidelines for Drinking-Water Quality (WHO 2011, version 2–3 at that time), the standards for new chemical substances were significantly updated, and guideline values based on lifetime carcinogenicity were provided. Second, both legally binding standards and targets for the standard value of lead were set, with effective, step-by-step targets, assuming that measures would take a long time. Third, the "monitoring items" section was established, and the process of monitoring new chemical substances and examining regulated substances on this basis was incorporated into the system.

Even after the introduction of such risk management methods, water quality problems have arisen, including new disinfectant by-products such as bromic acid and halogenated acetic acid, infectious diseases caused by chlorine-resistant microorganisms such as *Cryptosporidium*, and the presence of endocrine-disrupting chemicals and dioxins, in addition to trihalomethane. There are 4538 (as of 2019) water utilities in Japan, for which small-scale businesses often report health hazards due to improper disinfection methods. Additionally, in a large-scale water purification plant in the Tone River, there was an incident when water supply was cut off from 870,000 people because of the collection of aldehyde precursors (Asami et al. 2013). To deal with such situations, the Ministry of Health, Labour and Welfare established the provision of "Chemicals Difficult to Treat by Water Purification" in 2015. Other developments have also taken place, such as the proposal of quantitative analysis of microbial risk based on risk scenarios and integrated evaluation methods for microbial risk and chemical substance risk.

These water pollution issues have the characteristics of a typical environmental risk in that the unexpected and sudden damage is remarkable because the contamination occurs within a system with various interconnected factors. Local governments, such as the municipalities and prefectures that supply drinking water for domestic use as public water supply organizations, may therefore face risk-based decision-making challenges in supplying good quality tap water.

Risk management methods can be categorized as "ex ante" and "ex post." Ex ante methods are measures that address the cause of the damage before it occurs, while ex post methods are measures against the post-condition after the damage occurs. When the current water quality risk management methods are organized from an ex ante and ex post perspective, risk prevention is implemented in advance by public capital investment, such as through water purification treatment and a management system based on water quality standards. Subsequent allocations, such as compensation for damages by subsidies from the prefectural general account budget and subsidies for preventive investments made by water utilities, are also stipulated. If the cause of the damage can be attributed to a specific firm or water supplier, the ex post allocation is determined by the liability detailed in the lawsuit.

Chlorine-resistant pathogenic microorganisms, such as *Cryptosporidium* and other substances that are difficult to treat by water purification, occur intermittently, and chlorine disinfection is ineffective. This is a serious problem in water quality management, and simply applying ex ante risk management measures leads to the inevitability of water quality accidents.

In ex post methods, if the risk of contamination is intermittent or difficult to identify, then the system of allocating responsibility requires strict proof of the causal relationship, which increases transaction costs. Public subsidies from general accounts may sacrifice the efficiency of the burden and allocation in favor of compensation and preventive investment, and this can hinder people's risk reduction incentives.

Given that the current nature of such water pollution risks increases inefficiencies of current liability and public compensation schemes, it is worth considering a third approach to ex post management: insurance systems. The insurance system is expected to help lower transaction costs and improve risk reduction incentives through a premium price mechanism and eventually help achieve social efficiency. Viscusi (1992) pointed out that if ex post allocation can be used to incentivize preventive investment in advance, the functions of the ex ante method and the ex post method are mutually complementary. Previous research on risk sharing and resource allocation in ex post risk management include Sandler's (1993) work that analyses the functions of risk sharing through financial transfers and public goods, and Corne and Silva's (2000) study that analyses the system of interregional insurance and regional public goods in the federal system that extended the economic growth risks of EU countries. Lockwood (1999) discusses uncertainties about the demands, costs, and income of local public goods in terms of optimal subsidies and local public goods when there is information asymmetry between the central government and multiple local governments. Regarding environmental risk sharing, Konya (2001) focuses on the uncertainty of environmental issues and agricultural production and discusses the efficient design of agricultural mutual aid.

Based on the context discussed above, the purpose of this study is to examine the ex post risk management method for local governments facing risks related to water pollution to address the public investment cost of risk when supplying tap water. In Sect. 2.1, we categorize three ex post risk management methods. In Sect. 2.2, we analyze the efficiency of risk sharing using insurance contracts. Then, based on the implications of the analysis in Sect. 2.2, the applicability of insurance risk sharing in tap water pollution is discussed in Sect. 2.3.

2.1 Ex Post Risk Management Method

2.1.1 Institutional Types of Ex Post Management

The activities of households and businesses have various inherent risks such as loss of life, health, and property. If prior management of these risks is not effective, the ex post damage will be significant, thus impairing the financial stability of households and businesses. There is also the possibility of impairing basic survival and living ability, as well as affecting economic activities. Freeman et al. (2001) categorize ex post risk management schemes for transferring or sharing such risks to another party into three types: government benefit schemes, tort liability schemes, and insurance.

1. Government Benefit System

   The government benefit system refers to a public subsidy system in which the government provides compensation to lost households and businesses. Social insurance, unemployment insurance, long-term care insurance, national treasury subsidies, and local allocation tax grants (with the last two flexibly operating against disasters, etc.) are all categorized in this scheme. When looking at the subsidy system in terms of risk sharing, the notable feature is the emphasis on the fairness of burden rather than efficiency. In other words, it provides equal benefits to all beneficiaries at the same cost without discriminating against the financial position of the beneficiaries. The main source of funding for these subsidies is taxes.
2. The Tort Liability System

   The tort liability system is a mechanism for forcibly transferring risks from one entity to another by clarifying their responsibility. Thus, a person who has suffered a loss can use it to seek compensation through the judicial system from those who are responsible for the risk that caused the loss. The system deals with ex post risks to health, safety, and property based on regulations; the product liability law and the pollution and health damage compensation system are specifically included in it.
3. Insurance

   This is a system through which households and companies transfer the risk of damage from contracts to certain private insurance companies by paying insurance premiums. Insurance companies diversify their risks by paying future insurance benefits from the reserves that have accumulated premiums. Through this mechanism, insurance contracts can provide compensation for damage to property, disability, and loss of income. The insurance system covers a wide range of individual risks, such as life insurance, fire insurance, and liability insurance. For the insurance system to work, two conditions are required: insurability and marketability. Insurability is when risks that insurance companies are targeting can be priced properly as insurance premiums, which accurately reflect the risk attributes. To do so, it is necessary to be able to grasp risks quantitatively based on frequency and loss size (i.e., specify risks) and to set premiums according to the risk characteristics of the potentially insured persons (i.e., separate risks). Whether the risk can be specified quantitatively depends largely on scientific knowledge about the risk events. If the event that poses the risk is not scientifically elucidated, the frequency and magnitude of the loss cannot be determined, and neither can the premium be set. The marketability of insurance means that there is sufficient demand for supply prices offered by insurance companies. Insurance demand arises when the potentially insured person is risk averse and liability to a third party for compensation occurs. On the supply side, it is necessary that the risk can be quantified, the expected loss can be estimated, and the transaction cost for risk classification is not excessive.

2.1.2 Benefits and Limitations of the Ex Post Risk Management System

The main benefits and limitations of each of the three types of the risk management system are the efficiency between allocating benefits and the burden of funding and the size of the transaction costs required to determine insurance benefits. Efficiency between burden and allocation is achieved by a combination of the price and allocation such that there is a match between the willingness to pay (risk premium), in which the risk-averse individual maximizes utility, and the marginal cost of the risk-neutral insurance provider. To achieve efficiency, quantitative information and segregation of risks are indispensable. If the information is incomplete, the price deviates from the efficient level because of adverse selection or moral hazard. Here, the transaction cost represents the cost required to determine the burden and allocation (i.e., the cost required for collecting information, administrative procedures, litigation, etc.).

The three systems are characterized in terms of efficiency and transaction costs. Although the subsidy system is inefficient in terms of burden and allocation, it is characterized by low transaction costs. That is, since the funding is sourced through the tax system, the risk can be shared broadly at low cost. In addition, the transaction costs for decision-making are small because a certain amount of resources has already been secured for the benefits. On the other hand, because the burden and benefits do not always match the degree of risk exposure, the insured entity does not have the incentive to reduce the risk; hence, the price mechanism does not work well for efficient resource allocation.

The tort liability system using the judiciary system, in contrast to the subsidy system, has a high transaction cost; however, it is easier to achieve efficiency between burden and benefits. Since the system emphasizes the polluter pays principle, if the responsibility is verified, the benefits will be funded by the cause and then paid according to the exposure. However, the efficiency achieved here does not depend on the price mechanism, but rather on bilateral trading. In addition, since the burden of compensation is high when the party that is liable for causing the risk is accused, the risk reduction incentives also work to a certain extent. However, it is likely that this will increase the financial and time-related transaction costs, collection of information, and litigation that will make the responsible party and the victim correspond directly with each other.

Risk diversification utilizing a private insurance system lies between the two, the subsidy system and the tort liability system, and is a system that can enjoy the efficiency between burdens and benefits, as well as low transaction costs. In other words, the source of the benefits is from the insured who intend to share the loss, and the insurance policyholder who bears them receives the benefits so that efficiency by the price mechanism is achieved. Additionally, if the risks can be specified and separated, the transaction costs for determining the benefits are low. However, the efficiency and transaction costs are highly dependent on insurability and marketability. Insufficient quantitative identification and segregation of risks can lead to inefficient burdens and benefits because of adverse selection and moral hazard, or uncertainties in risk causality may result in high transaction costs. Therefore, the level of efficiency and transaction cost have a certain range. Figure 2.1 illustrates the conceptual positioning of the three systems in terms of efficiency (burden and benefit) and transaction costs.

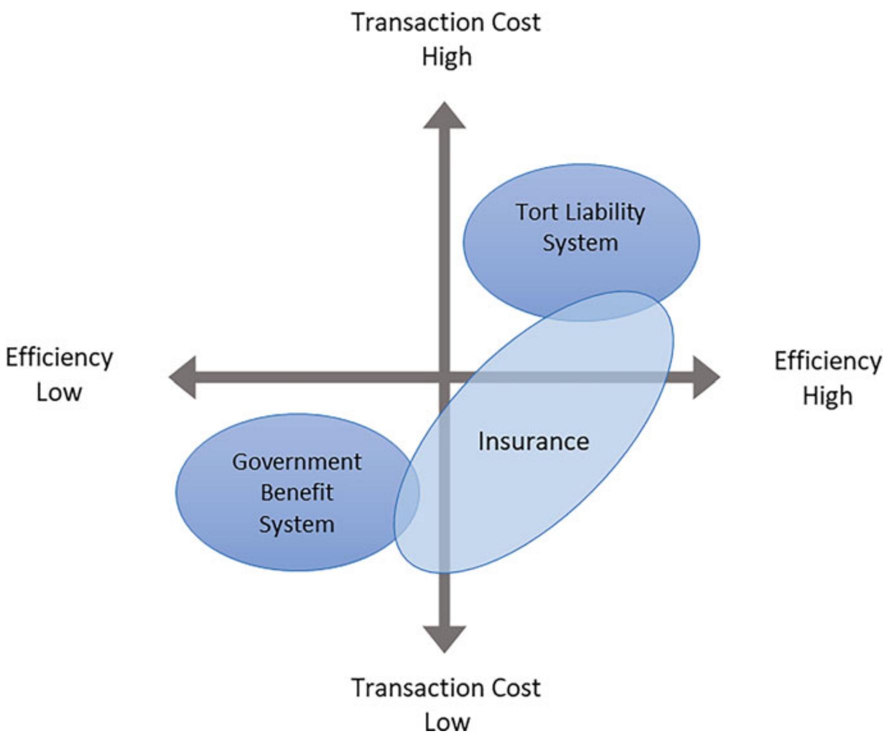

Fig. 2.1 Types of ex post management

2.1.3 Environmental Risk and Ex Post Management

In general, a specific characteristic of environmental risks is that it is often difficult to verify causal relationships because of uncertainty or unknowns because, for example, the toxicity evaluation of the substance is unknown, or because there are unknown aspects in the route to exposure. As a result, transaction costs for identifying risks increase. Therefore, the risk sharing by the tort liability system is likely to increase the legal element of the transaction cost. Comparatively, the low transaction cost of the subsidy system may offer a relatively better advantage. The transaction cost of insurance systems depends on the degree of uncertainty or unknowns. If the degree of uncertainty or unknowns is high, it is not possible to identify risks in detail and calculate the expected loss; hence, the precondition of insurance cannot be satisfied. Additionally, uncertainty increases insurance premiums, which may not satisfy the marketability condition. However, even if there is uncertainty, the provision of insurance is possible if certain risks can be identified. In such a case, the transaction cost is expected to be high in response to the degree of difficulty in identifying risks.

We compare the subsidy system and insurance, which are considered to be superior to the liability system with respect to transaction costs, from the viewpoint of the efficiency of burden and benefit. In the subsidy system, tax is a source of the subsidy money, so if the subsidy for the loss is regarded as an insurance benefit, the tax is a kind of compulsory premium. Therefore, when the distribution of subsidies (insurance benefits) is biased towards a specific taxpayer (insured), the inefficiency between burden and benefits increases. On the other hand, the insurance system is one in which the insured bears the insurance premium and is paid according to the identification of risks so that the efficiency between burden and benefits is maintained. However, if risk identification is inadequate, moral hazard and adverse selection will hinder efficient pricing. Therefore, the superiority of the subsidy system and the insurance system, in terms of efficiency, is determined by the degree of specificity of the targeted risks. When the transaction costs of risk are prohibitively high, the subsidy scheme is an efficient choice; in other words, if risks that are difficult to identify are considered noncompetitive and nonexclusive public goods because insurance cannot be provided, then efficient resource allocation is achieved by the subsidy system in which they are publicly borne as compulsory insurance. Conversely, if the transaction costs are low, the risk is regarded as an exclusive good that can be traded for ex post allocation, and applying an insurance system through which the potential insured bears the insurance premium can achieve more efficient allocation.