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Important Factors Influencing the Implementation of Independent Port State Control Regimes

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Abstract: This study investigated the factors influencing the implementation of a port state control (PSC) system. The analytical hierarchy process (AHP) was employed to develop a framework including 4 dimensions and 14 factors for assessing the priority of the major factors and subfactors. An expert questionnaire was conducted in Taiwan. The priority levels of the factors in influencing PSC operation are presented herein. In addition, conclusions were derived from an empirical case study of Taiwan. Some challenges are also discussed to reveal the common problems and special difficulties faced by independent PSC regimes that remain excluded from regional memoranda of understanding.

Keywords: port state control; port state control officer; marine safety; Tokyo memorandum of understanding; analytical hierarchy

1. Introduction

Port state control (PSC) is the inspection of foreign-flagged vessels in national ports to verify that ship conditions and equipment comply with international conventions and that ships are operated in compliance with applicable international laws. The flag state is primarily responsible for ensuring that ship standards comply with international conventions, but PSC provides a "safety net" to identify substandard ships [1]. If all flag states perform their duties satisfactorily, PSC would be unnecessary. Only when flag states fail to meet their commitments does the port state become involved. Control measures enacted under PSC are intended to complement national measures by flag state administrations and provide assistance to these administrations [2,3].

As a support for flag state implementation, PSC inspections have been proven to be extremely effective. The International Maritime Organization (IMO) adopted Resolution A.682(17) on regional cooperation for the control of ships to promote the conclusion of regional agreements. A ship traveling to a port in one country will typically visit other countries in the region. Therefore, it may be more efficient if inspections are closely coordinated to focus on substandard ships and avoid multiple inspections [1]. Harmonization in PSC inspection procedures is achieved through regional memoranda of understanding (MOUs), the first of which was the Paris MOU established in 1982. Subsequently, several other regional MOUs were established. The IMO has encouraged the establishment of these regional instruments for the harmonization and implementation of a global PSC regime. This was expressed by the promulgation of two IMO resolutions (Resolution A.787(19) as amended in Resolution A.882(21)) [1]. At present, the following nine MOUs cover virtually all seas of the world:

- Paris MOU, 1982 (Europe and the North Atlantic)
- Acuerdo de Viña del Mar, 1992 (Latin America)

- Tokyo MOU, 1993 (Asia and the Pacific)
- Caribbean MoU, 1996 (Caribbean)
- Mediterranean MOU, 1997 (Mediterranean)
- Indian Ocean MOU, 1998 (Indian Ocean)
- Abuja MOU, 1999 (West and Central Africa)
- Black Sea MOU, 2000 (Black Sea)
- Gulf Cooperation Council (GCC) MOU or Riyadh MOU, 2005 (the Arab States of the Gulf)

The United States Coast Guard (USCG) implements its own PSC regime [4]. Other authorities enforce their own PSC regimes because they have not joined any regional MOUs (so-called independent PSC regimes); for example, since 2003, Taiwan has implemented its own PSC inspections in accordance with applicable international standards established by competent international organizations (the IMO and the International Labor Organization (ILO)) or regional MOUs (Paris MOU and Tokyo MOU) [2].

Currently, classification societies are recognized organizations (ROs) that conduct convention-mandated statutory surveys and certification on behalf of flag state administrations. However, many substandard ships still traverse the world's oceans and do not or cannot adequately comply with international safety and pollution prevention standards. PSC is a safety measure designed to compensate for the shortcomings of ship owners, flag states, classification societies, and other actors. PSC provisions are featured in the United Nations Convention on the Law of the Sea (UNCLOS) and all major IMO and ILO conventions [5]. These provisions are as follows:

- UNCLOS Articles 94, 218, 219, 226, 230, and 231.
- International Convention for the Safety of Life at Sea Chapter I, Part B, Regulation 19, Control.
- International Convention on Load Lines, Article 21, Control.
- International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, Article X, Control.
- International Convention on Tonnage Measurement of Ships, Article 12.
- ILO 147 (Minimum Standards), Article 4.
- ILO Maritime Labor Convention, 2006, Article V.
- International Convention for the Prevention of Pollution from Ships, Articles 4–7.
- Annex I: Regulation 11, PSC on Operational Requirements.
- Annex II: Regulation 16, Measures of Control by Port State.
- Annex III: Regulation 8, PSC on Operational Requirements.
- Annex V: Regulation 8, PSC on Operational Requirements.
- Annex VI: Regulation 10, PSC on Operational Requirements.

Since the first PSC program was introduced by the IMO in 1982, PSC inspections have received increasing attention from researchers and policymakers. Yan and Wang [6] divided relevant research into four categories: (1) factors influencing PSC inspection results, (2) selection schemes for ship inspections, (3) effects of PSC inspection, and (4) methods for improving PSC inspections. The major purpose of this article is to investigate factors that influence PSC implementation by using analytical hierarchy process (AHP). Taiwan has implemented PSC inspections for more than 16 years (since January 2003) [7]. Because Taiwan's PSC regime remains outside the regional PSC system (i.e., Tokyo MOU), the researchers were eager to identify particular factors that influence independent PSC implementation. The remainder of the study is organized as follows: Section 2 reviews relevant literature. Section 3 presents a brief review of AHP techniques and the proposed AHP model for this research. Section 4 presents the empirical results of a Taiwanese case study. Finally, conclusions are presented, and the unique challenges of independent PSC regimes are discussed.

2. Literature Review

Some earlier studies on PSC have focused on its enforcement jurisdiction under international law and the enforcement of safety laws at sea. Molenaar [8] argued that the justifiability of extraterritorial port state jurisdiction relies not only on a sufficient jurisdictional basis but also on the type of implementation operation employed. In addition, port state jurisdiction is not only gradually shifting from an uncompelled basis on narrow subject areas toward an extensive and compulsory system based on regional and global organizations but also expanding in its acceptance as a countermeasure for the inability of flag states to effectively control their ships. Özçayır [9] explained how PSC can be used in the maritime industry and the Paris MOU. Moreover, some researchers have observed the effects of PSC inspections on environmental protection and have confirmed that PSC inspections can reduce marine environmental pollution [10].

When the legal foundation of PSC was established, the nine regional MOUs were promulgated in sequence. Researchers have conducted quantitative studies as more inspection data have become available. On the basis of data collected from the USCG, Paris MOU, and Tokyo MOU, Li and Zheng [11] investigated differences in maritime safety levels before and after PSC implementation. Two topics were explored: (1) PSC effectiveness, measured by total ship loss rates in maritime accidents, and (2) the efficiency of ship selection for inspection by regional PSC authorities, measured by detention–inspection rates. The study concluded that PSC implementation enhances the safety of maritime transport. Yang et al. [12] analyzed the game relationship between port authorities and ship owners under a new inspection regime by using inspection reports from the Paris MOU in 2015–2017; they proposed a risk-based game model between ship owners and port authorities to determine an optimal inspection policy. By using data from the Tokyo MOU, Tsou [13] discovered that "using association rule mining techniques in big data analysis can *precisely* and objectively determine the regularity correlation between ship detention deficiencies as well as between these deficiencies and related factors".

The establishment of regional PSC MOUs facilitates the enforcement of that system. Therefore, many studies have focused on its related challenges. Özçayır [9] argued that the uneven application of inspection standards is a problem for PSC; in addition, the subjectivity of PSC officers (PSCOs) in detaining vessels on the basis of their professional judgment represents a major drawback rooted in their background and training. Bloor et al. [14] also demonstrated that inspector background contributes to cross-national differences in inspection practices. After examining all regional MOUs with a focus on their strengths and weaknesses of operation, Bang and Jang [15] concluded that (1) the most successful regional MOUs are the Paris and Tokyo MOUs and (2) differences among the regional PSC MOUs generate an unavoidable problem in which vessels that are likely to encounter hindrances in a strong PSC jurisdiction will relocate to a region where PSC is less strict. The authors suggested the following improvements for this situation: (1) Mature MOUs and the IMO should work together to design means of preventing substandard ships from moving to regions where PSC is lax. (2) A formal system in which well-developed regional MOUs help less mature MOUs should be established through measures such as joint ministerial meetings to improve information exchange; annual conferences hosted by the IMO and involving all PSC committees in an MOU to harmonize activities; and augmented technical and financial help, such as inspector training.

Because PSC inspection is conducted by PSCOs, many studies have investigated the influence of inspector factors on inspection results, such as PSCO backgrounds [4,16], insufficient funds and personnel shortages [9], PSCO subjectivity in detaining vessels on the basis of their professional judgment [9,14], PSCO training programs [15], and the lack of teams to conduct inspections [17]. Ravira and Piniella [18] analyzed the influence of PSCO professional background in the Spanish Administration. By using European Union (EU) inspection data, [16] (2018) again confirmed inspection discrepancies in member states and team composition as well as in PSCO backgrounds. Nearly all regional MOUs require PSCOs to obey the "code of good practice" when performing inspections [19,20].

Although the first regional PSC MOU was established in 1982, problems in harmonization and PSC inspections persist. Through interviews with 14 key maritime stakeholders, Graziano et al. [17]

examined the EU PSC regime to identify the factors that cause differences in PSC enforcement among EU member states with a focus on the challenges and discrepancies of the Paris MOU. The major points discussed were PSCO background, inspection procedures, detention criteria, and PSCO training. At the member-state level, major factors that negatively influenced PSC inspections were "use of teams on board" and "training of PSCOs". At the inspector level, the major factors that contributed to discrepancies in inspection outcomes were related to the "background of the PSCOs" and their "professional judgment". Cariou and Wolff [21] developed a new methodology for improving target ship selection; target factors were previously investigated by Cariou et al. [22]. If the ship selection schemes adopted in PSC MOUs considered ship flag and classification society, Fan et al. [23] argued that PSC inspections increase the possibility of a ship being flagged out.

In its efforts to join the Paris MOU, Montenegro should first create a legislative framework and adopt international conventions related to PSC and then improve performance standards for PSC inspections through continual inspector training in compliance with the MOU, provide adequate equipment for inspections, and grant unrestricted access to the THETIS database; in addition, Montenegro must harmonize national legislation on PSC and cooperate more closely with members of the Paris MOU [24]. Similar to Montenegro, Taiwan has also not been allowed to join the Tokyo MOU for the following major reasons: (1) Taiwan has a unique international status and (2) its domestic maritime laws and regulations have not fully complied with international regulations issued by the IMO. Nevertheless, with the assistance of Canadian experts, Taiwan began PSC inspections in 2003 in accordance with related international conventions of the IMO and inspection procedures of the Tokyo MOU [2]. Liou et al. [25] suggested that an optimal solution for restructuring Taiwan's PSC inspection authority was to establish an independent governmental agency under the Ministry of Transportation and Communications; they also emphasized engagement in international cooperation.

3. Methodology

3.1. AHP

The AHP is frequently used to model subjective decision-making processes established on the basis of multiple criteria [26,27]. The AHP is widely used to study corporate planning, portfolio selection, cost–benefit analysis, group negotiation and conflict resolution, and international logistics center selection [28,29]. The steps of the AHP are summarized as follows:

(1) Develop a model for the decision: Establish the hierarchical system by separating the decision into a hierarchy of goals, criteria, and alternatives.
(2) Derive priorities for the criteria: Conduct a survey to collect input data, which consist of pairwise comparison matrices to determine the comparative weight among the attributes of decision elements.
(3) Derive local priorities for alternatives: Derive weights with respect to each criterion separately.
(4) Derive overall priorities: All alternative priorities obtained are combined as a weighted sum (by considering the weight of each criterion) to determine the overall priorities of the alternatives. The alternative with the highest overall priority constitutes the optimal choice.
(5) Perform a sensitivity analysis: A study of how changes in criteria weights may affect the result is performed to understand the rationale for the obtained results.
(6) Making a final decision: A decision can be made on the basis of the synthesis results and sensitivity analysis.

The AHP is a powerful instrument for decomposing complex decision-making problems and simplifying decision makers' cognitive burden; it has several underlying assumptions that must be investigated individually through specific decision-making problems. The AHP relies on numerous theories that validate empirical work; among these theories, rational choice theory plays a central role [30].

Although the AHP is functional and popular in both academia and professional life, various biases remain, and the method can be misused. Mu and Pereyra-Rojas [29] summarized some of the advantages and potential limitations of the AHP. The most crucial advantages included "(1) the ability of structuring a problem in a way that is easily manageable, (2) making the decision criteria explicit and the decision-making process transparent as a whole, (3) deriving priorities through a rigorous mathematical process using ratio scales, (4) allowing measuring and comparison of tangible and intangible elements and (5) allowing easy sharing of the decision-making process for feedback and buy-in". Regarding potential limitations, "(1) the comparison process may be long if the decision is complex, (2) the comparison judgment may be unreliable if the participants are not fully engaged in the process, and (3) the decision-making transparency may be counter-productive for managers who are interested in manipulating the results, and (4) group decision-making may make difficult to handle consistency problems".

3.2. Proposed Research Model

The AHP model is composed of several hierarchies and includes goals and criteria for various types of influence, subcriteria, and decision alternatives for determining the optimal alternative. Subcriteria under a criterion must be homogeneous before they can be mutually compared. Criteria in the same hierarchy must be mutually independent. Regarding the question of how much should one include in a hierarchy, Saaty [31] provided a general rule was that "the hierarchy should be complex enough to capture the situation, but small and nimble enough to be sensitive to changes". Some suggestions for an elaborate design are (1) to identify overall goal (i.e., what is the main question?), (2) to identify subgoals of overall goal, (3) to identify criteria that must be satisfied in order to fulfill the subgoals of the overall goal, and (4) to identify subcriteria under each criterion [27]. In order to apply the AHP methodology mentioned above to this study, a comprehensive review of PSC literature and consultations with practitioners was conducted, and then an AHP model for PSC was formulated as presented in Figure 1. The model includes four dimensions (i.e., major factors) and 14 factors (i.e., subcriteria in the hierarchy) which were considered a comprehensive framework and used to explore the importance of factors that influence PSC system implementation (Table 1).

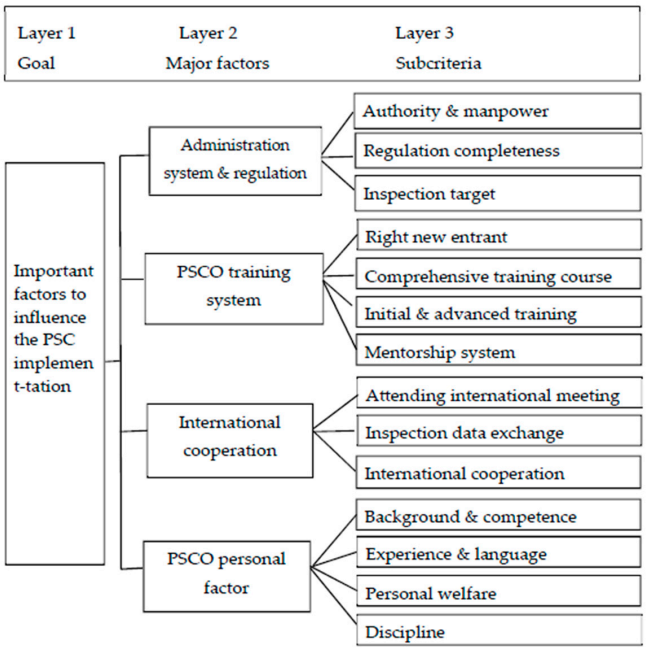


Figure 1. Analytical hierarchy process (AHP) model of factors that influence port state control (PSC) enforcement. Source: Proposed by the authors.

Table 1. Key factors influencing PSC regime operation.

Layer 2: Major Factors	Layer 3: Subcriteria	Sources
Administration system and regulation	Authority and manpower	[9,16,25]
	Regulation completeness	[6,15,17]
	Inspection target	[6,9,12]
PSCO training system	Right new entrant	[6,17]
	Comprehensive training course	[2,17]
	Initial and advanced training	[2,25]
	Mentorship system	Author's interview data
International cooperation	Attending international meeting	[2,7,24,25]
	Inspection data exchange	[2,7,9,24,25]
	International cooperation	[7,24,25]
PSCO personal factor	Background and competence	[2,4,9,12,14,17]
	Experience and language	[14,18]
	Personal welfare	[2]; Author's interview data
	Discipline	[19]; Author's interview data

Source: Compiled by authors.

3.3. Data Collection for Empirical Study

To obtain the comparative weights of the decision element attributes, an AHP questionnaire was designed to collect data. In total, 53 experts in Taiwan were invited to assess the comparative importance of factors related to the PSC inspection system in October 2019. Most of these experts (55%) directly conducted PSC inspections, and more than 64% had at least 5 years' experience of performing PSC inspection tasks (Table 2). Three PSCOs working at the Port of Keelung and Port of Taipei were invited for face-to-face interviews in October 2019.

Table 2. Information on expert respondents.

Profile of Expert Respondents		No.	%
Job content	Direct PSC inspection	29	55.00
	Indirect PSC inspection	24	45.00
	Total	53	100.00
Job responsibility	Full-time PSCO	3	5.66
	Part-time PSCO	50	94.34
Working location	MPA	8	15.09
	Keelung port	8	15.09
	Taipei port	6	11.32
	Suao port	2	3.78
	Taichung port	12	22.64
	Kaohsiung port	8	15.09
	Hualien port	4	7.55
	Anping port	3	5.66
	Others	2	3.78
Working experience in the organization	<5 years	19	35.85
	5–10 years	19	35.85
	11–20 years	7	13.21
	>20 years	8	15.09

Source: Compiled by authors.

4. Empirical Case Study Results

In addition to the AHP-based quantitative study, the researchers interviewed three PSCOs working at the Port of Keelung and Port of Taipei to obtain an in-depth understanding of current PSC inspections in Taiwan. The results of face-to-face interviews are presented along with the discussion of the major

factors and subcriteria in the AHP. In addition, statistical data on PSC inspections were analyzed to demonstrate the development of the PSC system in Taiwan.

4.1. Shipping Industry and PSC Inspection in Taiwan

Taiwan has well-developed shipping and port industries. In liner shipping, the four largest container carriers based in Taipei are Evergreen Marine Corporation, Yang Ming Marine Transport Corporation, Wan Hai Lines, and TS Lines, which were listed in the world's top 30 container carriers as of November 12, 2019 [32]. In addition, many bulk carriers provide tramp services. The ships controlled by Taiwan totaled more than 51.09 million deadweight tons (DWTs) in 2019, accounting for 2.6% of the total world's ship tonnage; although more than 88.94% of the ships were so-called flag-of-convenience ships [33]. The Port of Kaohsiung was ranked as the 14th top container port globally in 2018, with a throughput of 10.45 million twenty-foot equivalent units (TEUs) [34]. Because of its strong background in shipping and port industries, Taiwan must comply with the IMO's mandate for implementing PSC to jointly contribute to global shipping safety. Therefore, the survey data were considered appropriate for understanding PSC in practice.

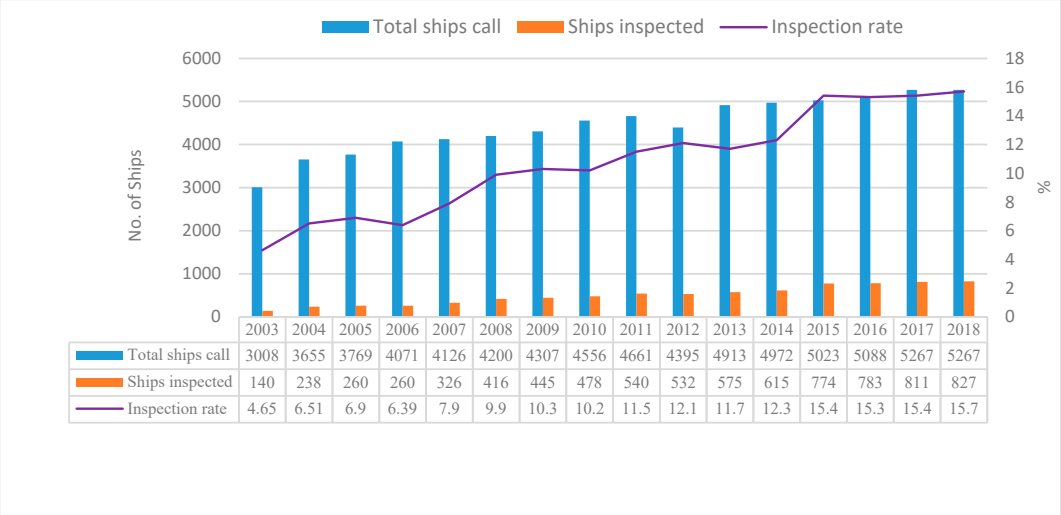
With the assistance of the Canadian Trade Office in Taipei and Canadian Coast Guard, Taiwan's central maritime authority (the Ministry of Transportation and Communications (MOTC)) launched its PSC system in 2003 [2]. The MOTC completed its port reform initiative in 2012 and established two new entities under its supervision: (a) the Maritime and Port Bureau (MPB) to act as a shipping and port regulator and administrator; and (b) the state-owned Taiwan International Port Corporation to be responsible for managing port facilities and services. Currently, PSC inspections are conducted by four maritime shipping centers (located in North (Keelung), Central (Taichung), South (Kaohsiung) and East (Hualien) Taiwan) of the MPB under the MOTC. PSCOs are governmental employees who specialize in navigation and ship engineering. Table 3 presents the labor allocation of Taiwan's PSCOs in 2018. In the field research of this study, interviewed PSCOs described a lack of labor to conduct PSC inspections. Moreover, many PSCOs were unwilling to remain in their current jobs because they lacked related benefits, such as risk insurance aboard ships, for conducting PSC inspections.

Table 3. PSCO labor allocation in 2018.

Organization	No. of PSCO
MPB (Ship Division)	1
North Maritime Shipping Center	10
Central Maritime Shipping Center	4
South Maritime Shipping Center	10
East Maritime Shipping Center	4
Total	29

Source: Adapted from [7].

Sixteen years after its implementation, the PSC regime of Taiwan appears to be stabilizing. First, the maritime authority has made efforts to increase the inspection rate to 15% of the total foreign ships that visit Taiwanese international commercial ports. Figure 2 indicates that the target inspection rate was reached over 2015–2018. The data in Table 4 reveal that, between 2015 and 2018, the number of inspected ships in Taiwan was similar to that in Hong Kong and Thailand, both of which are members of the Tokyo MOU.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total ships call	3008	3655	3769	4071	4126	4200	4307	4556	4661	4395	4913	4972	5023	5088	5267	5267
Ships inspected	140	238	260	260	326	416	445	478	540	532	575	615	774	783	811	827
Inspection rate	4.65	6.51	6.9	6.39	7.9	9.9	10.3	10.2	11.5	12.1	11.7	12.3	15.4	15.3	15.4	15.7

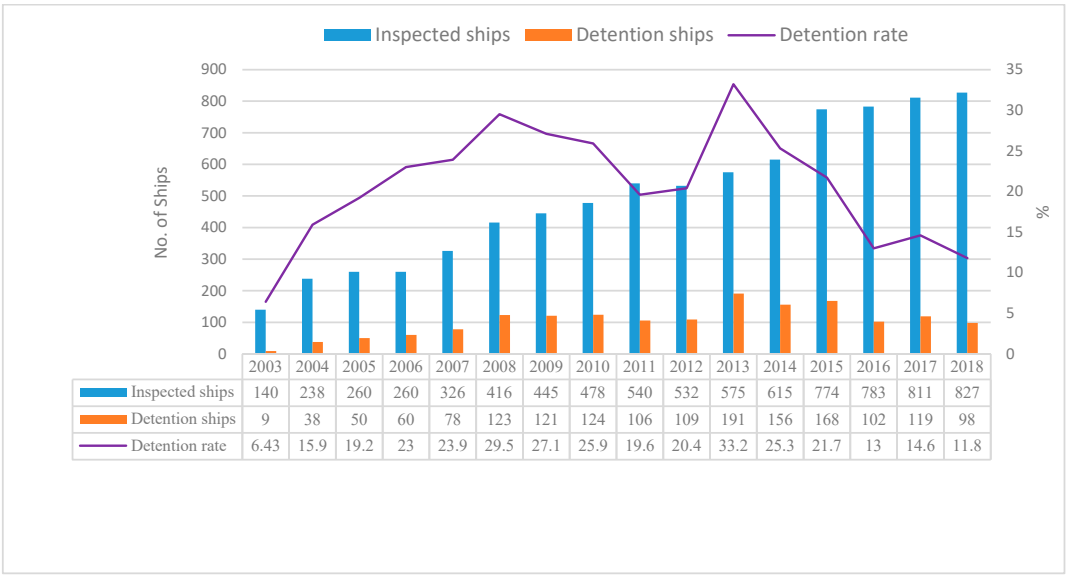
Figure 2. Ship inspection statistics. Source: Adapted from [7].

Table 4. Number of inspected ships for Taiwan, Hong Kong, and Thailand.

No. of Inspected Ships	Taiwan	Hong Kong	Thailand
2015	774	697	637
2016	783	630	634
2017	811	664	607
2018	827	716	669

Sources: [7,35].

The main purpose of PSC inspection is to improve maritime safety and eliminate substandard ships from the global shipping industry. As indicated in Figure 3, the detention rate of inspected ships in Taiwan steadily decreased from 33.2% in 2013 to 11.8% in 2018, suggesting that PSC inspections reduced the number of unsafe ships. However, if the Tokyo MOU is used as a benchmark, Taiwan's PSC system still has room for improvement in reducing the ship detention rate. As presented in Figure 4, the percentage of detained inspected ships for the Tokyo MOU has been less than 7% since 2008; however, the detention rate for Taiwan remains greater than 11.8%.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Inspected ships	140	238	260	260	326	416	445	478	540	532	575	615	774	783	811	827
Detention ships	9	38	50	60	78	123	121	124	106	109	191	156	168	102	119	98
Detention rate	6.43	15.9	19.2	23	23.9	29.5	27.1	25.9	19.6	20.4	33.2	25.3	21.7	13	14.6	11.8

Figure 3. Inspected ships and detention rates. Source: Adapted from [7].

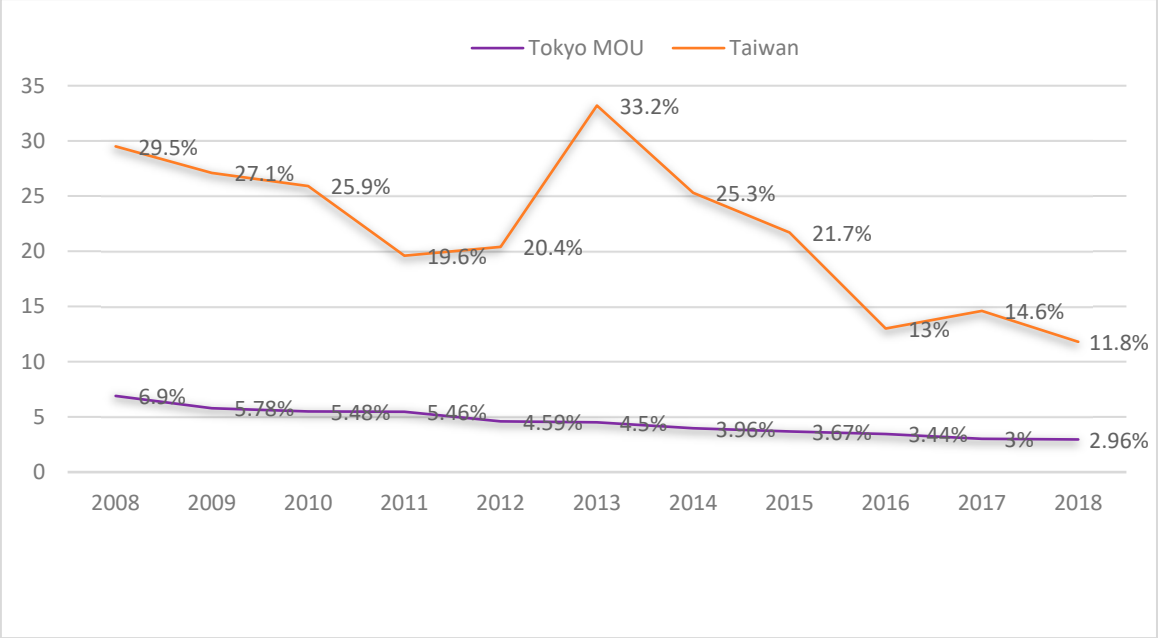


Figure 4. Detention rates: Taiwan and the Tokyo MOU. Sources: The data adapted from [7,35].

Regarding the deficiencies recorded in inspections, Table 5 indicates that among the 10 major deficiency categories, 8 were common to both the Tokyo MOU and Taiwan PSC inspection systems. This suggests that the PSCOs of Taiwan have received almost identical education and training to the Tokyo MOU members. With similar knowledge and training, PSCOs can easily learn from others and focus on similar items in PSC inspections.

Table 5. Major deficiencies according to main category, 2018: Taiwan and the Tokyo MOU.

Tokyo MOU		Taiwan	
Category of Deficiency	**% (Ranking)**	**Category of Deficiency**	**% (Ranking)**
Fire safety measures	17.79% (1st)	Safety of navigation	16.1% (1st)
Safety of navigation	13.51% (2nd)	Certificate and documentation	15.6% (2nd)
Life-saving appliances	12.49% (3rd)	Working and living conditions	13.2% (3rd)
Pollution prevention	9.23% (4th)	Life-saving appliances	9.3% (4th)
Certificate and documentation	8.99% (5th)	Fire safety measures	7.7% (5th)
Water/weathertight conditions	6.69% (6th)	Water/weathertight conditions	7.1% (6th)
Labor conditions	5.99% (7th)	Others	6.8% (7th)
Emergency systems	5.5% (8th)	Pollution prevention	5.5% (8th)
Propulsion and auxiliary machinery	5.04% (9th)	Radio communications	4.2% (9th)
Working and living conditions	3.38% (10th)	Emergency systems	3.4% (10th)

Sources: Calculation based on the data adapted from [7,35].

4.2. Major Factors and Subcriteria Ranking

As mentioned previously, an AHP questionnaire is designed to collect pairwise comparison evaluation data on PSC implementation factors from respondents (53 PSCOs). Then, pairwise comparison matrices are generated for estimating the scale of priorities (or weights); this scale is obtained by solving for the principal eigenvector of the matrix and then normalizing the result. In our case, Table 6 presents results of the local weights of 4 major factors and those subfactors under their respective parent criterion, as well as the global weight of each subcriterion.

Table 6. Composite priority weights for major factors and subcriteria.

Major Factors	Local Weights	Local Weights Ranking	Subcriteria	Local Weights	Local Weights Ranking	Global Weights (Subcriteria)
Administration system and regulation	0.2458	3	Authority and manpower	0.4091	1	0.1005
			Regulation completeness	0.3200	2	0.0786
			Inspection target	0.2709	3	0.0666
PSCO training system	0.2511	2	Right new entrant	0.1904	4	0.0478
			Comprehensive training course	0.2392	3	0.0601
			Initial and advanced training	0.2542	2	0.0638
			Mentorship system	0.3162	1	0.0794
International cooperation	0.1864	4	Attending international meeting	0.3481	1	0.0649
			Inspection data exchange	0.3242	3	0.0604
			International cooperation	0.3277	2	0.0611
PSCO personal factor	0.3167	1	Background and competence	0.2427	3	0.0769
			Experience and language	0.1755	4	0.0556
			Personal welfare	0.3062	1	0.0970
			Discipline	0.2756	2	0.0873
					Total	1.000

Source: Compiled by authors.

As shown in Table 6, the evaluative factor with the largest influence on PSC task operation is the PSCO personal factor, and its priority weight is 0.3167. The PSCO training system is the runner-up with a priority weight of 0.2511. The other two factors of the administration system and regulation as well as international cooperation have priority weights of 0.2458 and 0.1864, respectively. According to this result, the improvement of "PSCO personal factor" is the highest priority; the managerial implication is that if MPB plans to enhance its PSC implementation system, "PSCO personal factor" dimension should first be improved, followed by the PSCO training system and the administration system and regulation, etc.

Table 7 presents the results of scale normalization (i.e., the global weights of subcriteria) in descending order of priority. The relative importance of each subcriterion is based on its global weight. In this empirical case, the highest priority subcriteria were authority and labor (0.1005), personal welfare (0.0975), discipline (0.0873), mentorship system (0.0794), regulation completeness (0.0786), background and competence (0.0769), inspection target (0.0666), attending international meetings (0.0649), initial and advanced training (0.0638), international cooperation (0.0611), inspection data exchange (0.0604), comprehensive training course (0.0566), experience and language (0.0556), and right new entrant (0.0478). Practically, the data can be referred to for making decisions; for example, improvement measures should be firstly considered by MPB for those higher priority subcriteria if the PSC regime in Taiwan expects to become better.

Table 7. Priority weights of subcriteria.

Rank	Importance of Factors (Subcriteria)	Global Weights
1	Authority and manpower	0.1005
2	Personal welfare	0.0975
3	Discipline	0.0873
4	Mentorship system	0.0794
5	Regulation completeness	0.0786
6	Background and competence	0.0769
7	Inspection target	0.0666
8	Attending international meeting	0.0649
9	Initial and advanced training	0.0638
10	International cooperation	0.0611
11	Inspection data exchange	0.0604
12	Comprehensive training course	0.0566
13	Experience and language	0.0556
14	Right new entrant	0.0478

Source: Compiled by authors.

In the interviews, the three interviewees identified the following critical challenges related to PSC implementation in Taiwan.

(1) Labor power of PSCO: Currently, the number of PSCOs is insufficient to satisfactorily perform PSC inspections. Because all PSCOs are government employees and the selection and training of new officers occurs through governmental examinations, the rigid system limits some suitable applicants from becoming PSCOs; in addition, because government employees are promoted to other positions, senior PSCOs cannot continue ship inspections; as a result, the PSC system easily loses experienced personnel. The interview data were consistent with the questionnaire results, which revealed that the three crucial factors influencing the PSC system are authority and labor, PSCO personal welfare, and discipline (Table 7).

(2) PSCO training system: The current annual initial and advanced education and training courses are sufficient because they were arranged with the help of Canadian entities. However, the training schedule should change from the current 2 weeks per year. Instead, training should be held twice yearly or quarterly, which would allow PSCOs to attend training courses and not miss opportunities because of their tight work schedule. The questionnaire results (Table 7) also indicated that two dimensions, namely PSCO personal factors and PSCO education and training, are the most influential elements affecting the PSC regime.

(3) Regulations still lack completeness: According to an MPB report, the major regulatory foundation of Taiwan's PSC implementation is Articles 58, 59, and 60 of the Commercial Port Law and Article 101 of the Law of Ships, both of which allow the maritime authority to adopt and enforce relevant international conventions or agreements on PSC. However, PSCOs suggested that the aforementioned relevant international conventions or agreements regarding PSC should be codified in national laws and regulations. The empirical results also confirm the priority of "regulation completeness" among the top five categories (Table 7).

5. Conclusions and Discussion

5.1. Conclusions

This study explores a special PSC case and the empirical data also collected from ports of Taiwan located in the western Pacific Ocean. With its specific situation of implementing a PSC system outside regional MOUs, the results obtained from this research may not essentially apply to the other PSC regimes. Moreover, because this empirical investigation was conducted in Taiwan, the conclusions made in this study do not necessarily apply to the United States, which has an independent but highly developed PSC regime that cooperates and coordinates closely with regional MOUs.

From the perspective of PSC, this research investigated the factors that influence the implementation of PSC inspections. On the basis of relevant literature and an empirical study on Taiwan, an AHP model was formulated to include 4 dimensions and 14 factors that were considered to significantly influence the PSC operation. A triangulation study was adopted. Therefore, a questionnaire was designed to collect data from 53 respondents with jobs related to PSC inspection in Taiwan. Another face-to-face interview was conducted to obtain in-depth information. The main conclusions of this study are as follows:

(1) Since its initiation, PSC inspections have facilitated maritime safety enhancement and marine environmental protection by identifying substandard ships. By employing AHP analysis and an expert questionnaire, this study demonstrated that the "PSCO personal factor" dimension was the most influential among the four dimensions, followed by "PSCO training system", "administration system and regulation", and "international cooperation" (Table 6). These results concur with the studies discussed in Section 2 that emphasized the role of inspectors in PSC. Furthermore, Table 7 indicates that the five most highly prioritized factors that influence PSC operations are authority and labor, PSCO personal welfare and discipline, the mentorship system, and regulation completeness. Among these five factors, four are related to PSCOs; this information informs the organization of a suitable PSC system; inspectors' personal welfare and discipline should be prioritized, followed by training for PSCOs and the completeness of PSC regulations. Because the completeness of PSC regulations was considered a crucial dimension, independent PSC regimes (such as Taiwan) have an unfavorable position in performing PSC inspections outside regional MOUs and the IMO. In fact, Taiwan has faced difficulties in harmonizing its PSC regulations with international rules because it lacks direct connections with regional MOUs and the IMO [36].

(2) Although the PSCOs (in Taiwan) assessed the "international cooperation" dimension as the lowest priority (Table 6), the three subcriteria of "international cooperation" were still considered the second most crucial factors for PSC implementation. As indicated in Table 7, "attending international meetings", "international cooperation", and "inspection data exchange" were in the 8th, 10th, and 11th positions, respectively, among the 14 factors. PSC regimes underscore the harmonization of the ship inspection practices, which is why regional MOUs are established. As mentioned, Taiwan has implemented PSC inspections for more than 16 years. However, it still operates in an independent regime and is not included in the Tokyo MOU; therefore, more efforts are required to cooperate internationally with members of other regional MOUs.

(3) Although Taiwan's PSC system has not been accepted by the Tokyo MOU, it appears to be reaching maturity. Table 3 indicates that between 2015 and 2018, the number of inspected ships in Taiwan reached that of Hong Kong and Thailand. In terms of the 10 major inspection deficiencies, Taiwan's inspectors have recorded eight categories that the PSC inspectors of the Tokyo MOU have recorded (Table 4). A few reasons can explain this. First, Taiwan is prominent in shipping, and its government is committed to implementing a PSC system and harmonizing it with international practices. Second, well-developed network communication helps people obtain PSC information from the IMO or regional MOUs. Nevertheless, independent PSC regimes (particularly in the case of Taiwan) have drawbacks and gaps in obtaining data through informal channels. Third, Canadian experts provided assistance to establish Taiwan's PSC system in 2003 and have continued to offer annual education and training programs.

5.2. Discussion

Some common challenges for PSC systems and unique difficulties faced by independent PSC regimes (such as that of Taiwan, which is excluded from regional MOUs) are as follows:

(1) Because the Asia Pacific is a busy shipping area, numerous ships call into the ports in Taiwan; therefore, many ships are inspected by Taiwan's PSC inspectors (Figure 3). Because of the government's ambitions in fighting substandard ships, the detention rate is extremely high. Although the percentage of detained inspected ships has decreased from 33.2% in 2013 to 11.8% in 2018, it remains higher than

that of the Tokyo MOU of 4.5% in 2013 and 2.96% in 2018 (Figure 4). The reasons for the high detention rate warrant further study. Moreover, to address the high detention rate, the method of selecting target ships may require changing; some regional MOUs are considering a risk-based approach to replace the minimum percentage of inspections.

(2) The empirical results of this study indicate that international cooperation has little effect on Taiwan's PSC system; in Table 7, international cooperation was considered the lowest priority. However, PSC inspections have become a global shipping practice. Interactions among PSC authorities cannot be ignored. According to the ship profile assessment of the Tokyo MOU, Taiwan's independent PSC system is easily exposed to high-risk ships because of some inherent drawbacks. First, Taiwan's PSC system has not been accepted by the IMO for a formal audit. Although the maritime authority in Taiwan had conducted an audit of the maritime administrative sector on the basis of the IMO Member State Audit Scheme standards [35], the effect remained inconclusive because Taiwan is not an IMO member. This problem reveals the disadvantage of independent PSC regimes' exclusion from regional MOUs or the IMO. Second, ROs form a problem. The ROs of the Tokyo MOU are recognized by at least one member authority of the Tokyo MOU. Because Taiwan is not a member of the Tokyo MOU, it depends on other members' recognition of its classification society. Along with the joint efforts of the maritime authority and its classification society, the performance of Taiwan's RO (CR Classification Society) was evaluated as high during July 2019 to June 2020 [35].

We previously stated that PSC is viewed as a safety net designed to compensate for the shortcomings of ship owners, flag states, and classification societies. In reference to the two aforementioned challenges, we may conclude that (a) for a ship, maintaining high safety standards for inclusion in the white list is preferable to concern over whether its flag state is a member of the IMO; and (b) an RO should always achieve high performance in ship inspections instead of concentrating on the membership of its flag state.

(3) Some topics warrant future study. From a practical perspective, the IMO should provide assistance to maritime states that remain outside regional MOUs but have initiated PSC inspections (such as Montenegro in Europe and Taiwan in the Asia Pacific) for inclusion in the global maritime safety net through PSC regimes. Bang and Jang [15] suggested that well-developed MOUs and the IMO should further cooperate and propose approaches for preventing substandard ships from transferring to regions where PSC is enforced less aggressively. Moreover, a mechanism (formal or informal) can be established by advanced MOUs or the IMO to help authorities that remain outside regional MOUs but are eager to develop a sound system to implement PSC inspections to jointly reduce the number of substandard ships and protect the seas.

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