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The Impact of COVID-19 on Taiwan's Tourism Industry and Its Economic Linkages: An Input–Output Analysis

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Abstract

The COVID-19 pandemic has profoundly disrupted global tourism, with Taiwan's tourism industry experiencing unprecedented challenges due to international travel bans and strict domestic containment measures. This study examines the impact of COVID-19 on Taiwan's tourism sector and its economic linkages using input–output (I–O) analysis. The I–O framework, adjusted through the RAS method, enables the estimation of sectoral interdependencies and multiplier effects across the Taiwanese economy from 2016 to 2019. Tourism-related industries—specifically wholesale and retail, accommodation and dining, transportation services, and entertainment—are evaluated in terms of backward and forward correlation effects, total industry linkages, and standardized measures of influence and sensitivity. The findings reveal that Taiwan's tourism-related industries occupy a relatively modest position in the national economic structure, with weaker forward linkages that limit their capacity to serve as foundational suppliers for other industries. Retail and accommodation rank low in both forward and backward effects, while transportation and entertainment demonstrate moderate backward linkages, reflecting their role in stimulating upstream industries. The construction sector, though not directly categorized as tourism, exhibits the strongest backward correlation, underscoring its role as a complementary driver amplified by tourism development. The results highlight the vulnerability of Taiwan's tourism sector to external shocks yet affirm its potential to stimulate complementary industries. Policy implications emphasize the need for resilience-building, diversification, and alignment of tourism strategies with broader industrial development goals.

JEL classification numbers: C67, E01, O53, Z32.
Keywords: Tourism Industry, COVID-19 Pandemic, Input–Output Analysis, Economic Linkages.

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1. Introduction

The COVID-19 pandemic has precipitated a severe global crisis for the tourism and hospitality sectors. International travel bans affected over 90% of the global population, and, combined with social distancing measures, effectively brought tourism to a standstill by March 2020. Empirical evidence indicates that the lockdown measures imposed between 2 and 29 March 2020 may have averted approximately 3.1 million deaths across 11 European countries (Flaxman et al., 2022). These interventions—ranging from social distancing, prohibitions on large gatherings, and school closures to restrictions on all but essential travel—successfully reduced COVID-19's reproduction rate (R0) to below 1, declining from about 0.44 in Norway to 0.82 in Belgium, with a European average of 0.66. This represented a reduction of more than 80% compared to pre-lockdown levels. A complementary study further estimated that similar measures adopted in China, South Korea, Italy, Iran, France, and the United States prevented or delayed approximately 530 million infections (Hsiang et al., 2020).

As most countries gradually emerge from lockdown, the tourism sector continues to face severe constraints due to reduced international connectivity, in-flight social distancing requirements—often limiting airplanes to half their nominal capacity—and other restrictions imposed in response to the persistent presence of the virus (Gössling, Scott, and Hall, 2020). The United Nations World Tourism Organization (UNWTO) projected that in 2020 international tourism would decline by nearly 80%, resulting in revenue losses amounting to trillions of U.S. dollars. Reflecting these trends, the World Travel and Tourism Council (WTTC) highlighted the cascading economic repercussions of COVID-19, warning that the crisis threatens the livelihoods of approximately 300 million people employed in the global tourism and hospitality industry—representing nearly one-tenth of the world's workforce—and jeopardizes an industry that contributes almost 10% of global GDP (Broom et al., 2023).

The tourism industry, often described as a "chimney-free industry," is highly valued worldwide and has shown continuous growth, except during major crises such as the 2001 global recession, the 2003 Iraq war, and the SARS outbreak. According to the World Travel & Tourism Council (WTTC), tourism and related industries accounted for 11.6% of global output in 2007 and were expected to reach 12% by 2010, highlighting their growing role in global economic development. Tourism generates significant employment and added value—often exceeding that of agriculture and industry in advanced economies—making it one of the world's largest industries.

Beyond economic contributions, tourism attracts foreign investment, stimulates trade, promotes urbanization, and creates jobs, while imposing relatively low external costs. Its influence extends across multiple sectors, including transportation, hospitality, catering, retail, and entertainment, making it a comprehensive industry with strong interdependence among sectors. Furthermore, tourism leverages natural and cultural resources to showcase national economic strength, modern

infrastructure, and cultural quality, thereby reinforcing both economic growth and international image.

This study aims to investigate the extent to which Taiwan's tourism industry affects the national economy by applying the input–output model to analyze industrial linkages and multiplier effects. Specifically, it asks: What is the interdependent relationship between tourism and other industries, and what position does tourism occupy within Taiwan's economic structure? How do the income, output, and employment multipliers of the tourism industry reflect its overall contribution to economic growth? Finally, how can these findings inform government policy and guide the future development of Taiwan's tourism industry to enhance its role in national economic development?

2. Literature Review

2.1 Tourism Industry

The tourism industry can be broadly defined as the set of activities and services that enable the integration of tourists with tourism resources, thereby allowing them to achieve their travel objectives (Liang et al., 2025). It emerges through the transformation of tourism resources into structured tourism areas and is characterized by consumers who are diverse and highly sensitive to changing demands. Due to its relatively low level of environmental pollution, the tourism sector is often referred to as a "chimneyless industry" (Chang and Chang, 2013). Similarly, the Wharton Econometric Society defines tourism as encompassing all activities related to travel, accommodation, transportation, catering, and entertainment, including hotels and other lodging facilities, passenger transportation, restaurants and food services, as well as leisure and cultural services. Collectively, these definitions highlight tourism as a comprehensive, service-oriented industry with wide-ranging economic and social significance.

According to the Ministry of Transportation and Communications (2007), the tourism industry is defined as *"the development, construction, and maintenance of tourism resources; the enhancement of tourist facilities; the provision of services and conveniences for travel and accommodation; and a broad range of service industries associated with international conferences and exhibitions."* Expanding on this, Wang and Yotsumoto (2019) emphasized that the development and promotion of tourism inevitably involve sectors such as housing construction, public works, and other related infrastructure projects, which become directly affected when a country prioritizes tourism development.

To clarify the scope of the tourism industry, Wolf, Ainsworth, and Crowley (2017) identified five defining characteristics: intangibility, heterogeneity, perishability, inseparability, and ease of imitation. These attributes underscore the complexity of the tourism sector, positioning it as a comprehensive industry that spans multiple domains. Consequently, in the *Industry Classification Standards* of the Comptroller and Accounting Office, tourism is not listed as a distinct category but is instead distributed across various sectors, including entertainment, hotels, transportation,

catering, and cultural services. Since the National Income Account classifies industries based on production activities, tourism-related industries appear fragmented and complex, though the core directly related sectors remain largely consistent across countries.

The tourism industry can be categorized into a broad and a narrow sense. In the broad sense, it encompasses a wide range of sectors, including food, clothing, housing, transportation, education, and entertainment, thereby covering a far wider scope than most other industries. In this view, tourism-related activities are highly fragmented, involving an estimated 120,000 industries as well as government agencies, local administrative bodies, and other state-owned enterprises (Wang, 2009).

In contrast, the narrow definition, as outlined by the Ministry of Transport in the *2002 Transport Policy White Paper: General Introduction*, classifies the tourism industry into three main categories: (1) the travel industry, which arranges passenger travel, purchases transportation tickets, handles visa procedures, and provides related services; (2) the hotel industry, which operates international tourist hotels and first-class hotels to offer accommodation and related services; and (3) the tourism amusement industry, which manages sightseeing and amusement facilities approved by the government.

2.2 The Application of Input-Output Analysis in the Tourism Industry

Input–output (I–O) analysis is a widely used economic methodology designed to capture the interdependencies among industries within an economy. Originally developed by Leontief (1986), the approach relies on the construction of an input–output table, which records the flows of goods and services between sectors of production. By employing the table of industry-related transactions, the matrix of input–output coefficients, and measures of inter-industry linkages, researchers can infer how changes in final demand affect the total output of the economic system. In essence, I–O analysis provides a comprehensive framework for estimating the ripple effects across different industries when one sector experiences growth or contraction.

In the context of tourism, this methodology is particularly valuable because of the industry's diverse and fragmented structure. Tourism does not exist as a single, homogeneous sector; rather, it encompasses a wide array of related industries such as accommodation, transportation, catering, retail, and cultural services. When demand for tourism-related activities increases—such as through higher visitor arrivals or greater household spending—this stimulates not only the directly related industries but also numerous upstream and downstream sectors. Conversely, downturns in tourism demand, such as those caused by pandemics, natural disasters, or global recessions, can transmit negative shocks throughout the broader economy. The I–O model provides a systematic means of capturing these interlinkages.

A core feature of I–O analysis is the estimation of multiplier effects. In addition to measuring the output effect—that is, the increase in total production across

industries due to changes in demand—the framework also captures employment and income effects. These are often more significant from a policy perspective, as they reveal how job creation, household incomes, and overall welfare are influenced by tourism growth (Miller and Blair, 2009; Wang et al., 2006). Multiplier analysis, sometimes referred to as "impacts analysis," thus allows governments and researchers to quantify not only direct benefits but also indirect and induced effects. For example, an increase in tourist spending at hotels leads to higher demand for food suppliers, cleaning services, utilities, and entertainment, which in turn generates additional jobs and incomes in those supporting industries.

Beyond multipliers, the I–O framework with Dazing diversity also enables analysis of industrial linkages. By using industry relevance tables, researchers can assess forward and backward linkages to identify "key" or "leading" industries that have the greatest capacity to stimulate economic growth (Huber et al., 2012). Industries with strong backward linkages draw heavily on inputs from other sectors, thereby generating demand across the economy, while those with strong forward linkages provide essential inputs to multiple industries, supporting their production. For tourism, identifying such linkages is crucial for prioritizing investments and designing strategic development policies. For instance, if the tourism sector is found to have strong forward linkages through its reliance on transport and cultural services, targeted investments in these areas could yield disproportionate benefits for the economy.

Empirical research has applied I–O analysis extensively to tourism. Archer (1995) examined the economic impact of tourism in the Seychelles and demonstrated how the method can provide reliable estimates of employment multipliers and income effects in small island economies. Similarly, Fletcher (1989) highlighted the usefulness of I–O models in measuring tourism's role as a generator of foreign exchange and employment in developing countries. More recently, Li, Blake, and Cooper (2010) applied dynamic I–O models to assess the long-term impacts of tourism growth in the UK, showing how different types of tourist expenditures influence various sectors differently. These studies illustrate that I–O analysis remains an indispensable tool for both academic research and government policymaking in tourism economics.

The application of input–output analysis to the tourism industry allows for a systematic examination of how tourism interacts with other sectors, not only through direct spending but also through indirect and induced effects. By quantifying output, income, and employment multipliers, as well as forward and backward linkages, I–O analysis provides critical insights into the role of tourism as a driver of economic development. This study builds on these foundations by applying the I–O framework to Taiwan's tourism industry, thereby contributing to a better understanding of its position within the broader national economy and offering valuable evidence to inform policy and strategic planning.

2.3 History and Status of Taiwan's Tourism Industry

Taiwan's tourism industry has developed in close connection with broader global economic and political changes. Since the late 20th century, tourism has been recognized as an important service sector contributing to national income, employment, and foreign exchange earnings. Despite occasional setbacks caused by regional or global crises—such as the 2001 global economic downturn, the 2003 SARS outbreak, and the 2008 global financial crisis—Taiwan's tourism sector has demonstrated resilience and a long-term growth trajectory.

During the early 2000s, Taiwan began implementing policies aimed at positioning tourism as a pillar industry. The government invested in infrastructure, improved transportation networks, and promoted Taiwan as a cultural and ecological destination. These efforts were complemented by initiatives to increase cross-strait tourism, which opened the market to Chinese visitors and contributed significantly to arrivals and foreign exchange earnings. According to the Tourism Bureau (2009), despite the global recession in 2008, Taiwan still recorded positive growth in inbound tourists, with arrivals increasing by 3.47% and leisure tourism by 7.69%, highlighting the sector's relative competitiveness.

In terms of global competitiveness, the World Economic Forum's *Travel & Tourism Competitiveness Report* (2007) ranked Taiwan 30th worldwide and fourth in Asia, marking the first time Taiwan was included in a global assessment of tourism competitiveness. This recognition underscored Taiwan's potential as a strong regional tourism destination, with comparative advantages in cultural resources, natural attractions, and infrastructure.

Tourist arrivals to Taiwan increased steadily throughout the 2010s, reflecting both government promotion and rising regional mobility. In 2011, inbound visitors totaled just over 6 million, generating approximately USD 11.1 billion in expenditures. By 2019, arrivals had reached 11.8 million, with foreign exchange earnings exceeding USD 14.4 billion. However, the sector remained sensitive to external shocks. For example, fluctuations in political relations with mainland China significantly influenced the number of Chinese tour groups, while global events such as the COVID-19 pandemic in 2020 abruptly curtailed international arrivals, reducing them to historically low levels.

The structure of Taiwan's tourism industry is characterized by its interconnection with a wide range of service and manufacturing sectors. The core industries include accommodation, catering, retail, transportation, and entertainment, but its spillover effects extend into construction, cultural industries, and local services. This interdependence underscores the importance of analyzing tourism not as an isolated sector but as a driver of broader economic activity. Moreover, the government has increasingly promoted niche tourism segments such as eco-tourism, cultural tourism, medical tourism, and meetings, incentives, conferences, and exhibitions (MICE) to diversify the industry and reduce reliance on traditional package tours.

Taiwan's tourism industry has grown into a strategically important sector that plays a pivotal role in economic development, international image building, and cultural

exchange. Its historical evolution demonstrates both resilience and vulnerability, with periods of robust expansion tempered by external shocks. This dual character highlights the necessity of comprehensive economic analysis—such as input–output modeling—to understand tourism's broader impact on national development and to guide future policy directions.

2.3.1 Taiwan's Position in The International Tourism Market

The World Economic Forum (WEF), in its *Travel & Tourism Competitiveness Report* (2007), assessed Taiwan's tourism sector for the first time in a global context. Taiwan achieved an overall Travel & Tourism Competitiveness Index (TTCI) score of 4.82, ranking 30th worldwide and fourth in Asia. This was a significant milestone, as Taiwan had previously been excluded from global tourism appraisals due to its non-membership in the World Tourism Organization (UNWTO) and the World Travel & Tourism Council (WTTC). The inclusion of Taiwan in this assessment provided an authoritative benchmark for both government decision-makers and industry stakeholders, offering new perspectives on the island's comparative strengths and areas requiring policy attention.

Taiwan's performance in the TTCI reflects its growing competitiveness within the Asia-Pacific region, particularly in terms of infrastructure, cultural resources, and service capacity. Although not yet ranked among the leading global destinations, its position demonstrates both strong potential and development opportunities. The report also highlighted Taiwan's capacity to attract international visitors despite geopolitical constraints and limited participation in global tourism organizations. This indicates that Taiwan not only benefits from favorable conditions for tourism development but also holds significant untapped potential in leveraging its cultural heritage, natural landscapes, and strategic geographic location. The 2007 ranking, therefore, represented a landmark recognition of Taiwan's tourism industry as a viable and competitive sector in the global arena. For policymakers, the TTCI outcome provides a crucial reference point for formulating strategies to enhance Taiwan's international visibility, strengthen destination branding, and solidify its role as an emerging hub for international tourism in Asia.

2.3.2 The Current Situation of Foreign Tourists Visiting Taiwan

Over the past two decades, Taiwan has experienced a steady increase in the number of inbound tourists, largely as a result of government initiatives to enhance infrastructure, diversify tourism products, and improve international promotion. Policies promoting cultural tourism, eco-tourism, and cross-strait exchanges have further contributed to the steady rise in visitor arrivals. As shown in Table 1, the number of foreign tourists grew consistently from 2011 to 2019, with arrivals more than doubling over this period and generating substantial foreign exchange revenues. By 2019, international arrivals had reached nearly 11.9 million, representing a significant achievement for Taiwan's tourism sector and underscoring its growing global attractiveness.

However, the trajectory of growth was sharply disrupted in 2020 with the onset of the COVID-19 pandemic. Travel restrictions, border closures, and international flight suspensions led to a dramatic decline in arrivals, mirroring global patterns in tourism collapse. The unprecedented downturn not only slowed Taiwan's inbound tourism growth but also revealed the industry's vulnerability to external shocks, despite strong domestic foundations. Nevertheless, Taiwan's handling of the pandemic, combined with its reputation for safety, healthcare, and stability, may provide opportunities for recovery once international travel resumes. The experience also underscores the importance of building resilience in the tourism sector, such as by diversifying source markets, promoting domestic tourism, and adopting digital and innovative strategies to engage international travelers in the post-pandemic era.

Table 1: Statistics of Foreign Exchange Income from Tourism over the years

Year	No. of Visitors	Visitor Expenditures (US$)	Growth Rate (%)	80Y=100 Index 1991=100
2011	6,087,484	11,065,000,000	26.91	548.32
2012	7,311,470	11,769,000,000	6.36	583.20
2013	8,016,280	12,322,000,000	4.70	610.60
2014	9,910,204	14,615,000,000	18.61	724.23
2015	10,439,785	14,388,000,000	-1.55	712.98
2016	10,690,279	13,374,000,000	-7.05	662.74
2017	10,739,601	12,315,000,000	-7.92	610.26
2018	11,066,707	13,705,000,000	11.29	679.14
2019	11,864,105	14,411,000,000	5.15	714.12
2020	21,177	---	---	---

Source: Tourism Bureau, Ministry of Transport

Note: The figures for 2011 to 2020 are derived from the R.O.C. Outbound Travelers Survey. The data for 2019 comes from the Survey of Travel by R.O.C. Citizens. Starting in 2020, the figures are based on statistics from the Central Bank of the Republic of China (Taiwan) regarding foreign travel.

3. Research Method

3.1 Sectoral Aggregation and the Challenge of Identifying Tourism Impacts

The Chief Accounting Office of the Executive Yuan released the 2016 Industry Association in 2017, which classified the economy into 63 sectors and 164 subsectors (Table 2). Given the large number of categories, analyzing the interrelationship between the tourism industry and other industries requires simplification to ensure feasibility and clarity. Some tourism-related sectors are not explicitly distinguished in the 63-sector framework. For instance, the retail sector, which is closely tied to tourism, is merged with wholesale into a single category of "commodity trading business." Such aggregation limits the precision of economic analysis, as it prevents the isolation of tourism-specific contributions within the broader retail sector.

Table 2: Comparison of 10-Category and 63-Sector Classifications of Taiwan's Industry (2016)

Categories	Sectors		Categories	Sectors	
01 Agriculture, Forestry, Fishery, and Animal Husbandry	01	Agricultural Products	07 Construction and Utilities	31	Electricity and Steam
	02	Livestock Products		32	Gas
	03	Forest Products		33	Tap Water
	04	Fishery Products		34	Pollution Remediation
	05	Mineral Products		35	Construction Project
02 Traditional Manufacturing	06	Food and Feed	08 Wholesale and Retail	36	Wholesale
	07	Beverages and tobacco		37	Retail
	08	Textile	09 Accommodation and Dining	38	Lodging
	09	Garments and Accessories		39	Repast
	10	Leather, Fur and Other Products	10 Other Service	40	Land Transportation
	11	Wood and Bamboo Products		41	Water Transport
	12	Pulp, Paper, and Paper Products		42	Air Freight
	13	Printing and Data Storage Media Reproduction		43	Transportation Assistance and Storage
3 Petrochemical Industry	14	Petroleum and Coal Products		44	Postal and Courier
	15	Chemical Material		45	Publishing Audio Visual Production and Dissemination
	16	Other Chemicals		46	Telecommunications
4 Other Manufacturing	17	Pharmaceuticals and Medical Chemicals		47	Computer-related and Information Services
	18	Rubber Products		48	Financial Services
	19	Plastic Product		49	Insurance
	20	Non-Metallic Mineral Products		50	Securities Futures and Financial Assistance
	21	Furniture		51	Real Estate
	22	Other Products		52	Residential Services
05 Metal and Made from Metal	23	Basic Metal		53	Professional, Scientific and Technical Services
	24	Made from Metal		54	Leasehold
06 Electronics, Machinery and Transportation Equipment	25	Electronic Components		55	Other Support Services
	26	Computers, Electronic Products and Optical Products		56	Public Administration and National Defense; Mandatory Social Security
	27	Power Equipment and Equipment		57	Education
	28	Mechanical Equipment		58	Medical Insurance
	29	Automobile and Components		59	Social Work Service
	30	Other Transportation Vehicles and Components		60	Arts, Entertainment and Leisure Services
				61	People's Organizations and Other Social Services
				62	Housework Service
				63	Uncategorized Other Services

Source: Yuan (2016) compiled by this research

To address this issue, the present study reorganizes the 63 sectors into 10 broader categories for input–output analysis, while ensuring that tourism-related industries are more clearly delineated. This restructuring provides a clearer analytical framework, allowing for a more precise evaluation of the tourism industry's linkages with other sectors and its role in Taiwan's economic system. The classification is based on the following principles:

1. **Consistency with national accounts:** In compiling and processing industry association tables, excessive disaggregation can hinder data usability. Therefore, this study aligns its sectoral classification with that used in the national income accounts, ensuring consistency and improving the accuracy of estimates.
2. **Relevance to** research **objectives:** Sectors directly related to tourism are classified separately to better capture their distinct economic effects. Accordingly, four industries are isolated: *retail, transportation services, catering and hotel services*, and *film, arts, and entertainment services.*
3. **Consideration of** industrial **characteristics:** The classification also accounts for production structure, product usage, and technological differences. Industries with similar input structures and technologies are grouped, while those with different uses—likely to generate distinct forward or backward correlation effects—are classified separately (Wu, 2013).

4. Analysis and Result

4.1 Input–Output Coefficient

The adjusted input-output coefficients for 2016–2019, calculated using the RAS method, along with the official 2016 table published by the Chief Accounting Office of the Executive Yuan, provide the foundation for this study's analysis of Taiwan's industrial linkages. The input–output model allows for examination of these linkages from two perspectives: the backward correlation effect on the demand side and the forward correlation effect on the supply side (Steinback, 2004). From the demand side, the analysis reveals the sources of inputs and the input structure of a given industry, while from the supply side, it illustrates the destinations and allocation structure of its outputs. Together, these perspectives help clarify the total demand for and supply of resources generated across Taiwan's industrial sectors.

To capture the broader picture, the total correlation effect—defined as the sum of backward and forward linkages—can also be assessed, providing a comprehensive view of industrial interdependencies. In this study, particular attention is given to the interconnections between tourism-related industries and other sectors of the economy. By comparing these effects, it becomes possible to determine whether tourism-related industries function as "leading industries," capable of driving growth in upstream and downstream sectors, or as indispensable "basic industries" that provide essential support for broader economic activity.

The results of such an analysis are not only of academic interest but also of practical policy significance. Understanding the relative position of tourism-related industries within Taiwan's industrial structure enables policymakers to identify

sectors with high economic influence and prioritize investment accordingly. In doing so, the government can more effectively channel resources into industries where tourism development generates strong multiplier and linkage effects, thereby accelerating both the growth of the tourism industry itself and its contribution to Taiwan's overall economic development.

4.1.1 Backward Correlation Effect

The backward correlation effect measures the extent to which an industry stimulates the development of upstream industries through its demand for intermediate inputs. A higher backward correlation value indicates a stronger capacity to "drive" overall industrial development, positioning the sector as an important downstream industry (Fu et al., 2010). Based on the adjusted input–output coefficient tables for 2016–2019, this study calculates the four-year backward correlation effects, as presented in Table 3. The results show that Taiwan's industrial structure has remained relatively stable during this period, with most industries experiencing growth rate fluctuations of around 1%. Only the hydropower and gas sector and the wholesale and international trade sector recorded more pronounced increases, with growth rates of 3.6% and 7.2%, respectively.

Table 3: Backward Correlation Effects in Taiwan (2016~2019)

No.	Industry	Backward Correlation Effect						
		Value				Growth Rate		
		2016Y	2017Y	2018Y	2019Y	2017Y	2018Y	2019Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	1.722983	1.714955	1.740729	1.754084	-0.47%	1.50%	0.77%
02	Traditional Manufacturing	1.445023	1.439911	1.410442	1.419137	-0.35%	-2.05%	0.62%
03	Petrochemical Industry	1.816698	1.852198	1.873958	1.923726	1.95%	1.17%	2.66%
04	Other Manufacturing	2.074615	2.064399	2.059924	2.086657	-0.49%	-0.22%	1.30%
05	Metal and Made from Metal	1.564795	1.596069	1.592088	1.614852	2.00%	-0.25%	1.43%
06	Electronics, Machinery, and Transportation Equipment	1.584418	1.535462	1.501593	1.499158	-3.09%	-2.21%	-0.16%
07	Construction and Utilities	1.363606	1.364572	1.358634	1.369585	0.07%	-0.44%	0.81%
08	Wholesale and Retail	1.537150	1.592590	1.707941	1.917980	3.61%	7.24%	12.30%
09	Accommodation and Dining	1.483264	1.486835	1.496780	1.531694	0.24%	0.67%	2.33%
10	Other Service	1.425082	1.427043	1.420899	1.423405	0.14%	-0.43%	0.18%
Total		16.01763	16.07403	16.16299	16.54028			
Average		1.601763	1.607403	1.616299	1.654028			

Focusing on tourism-related sectors, which include wholesale and retail, accommodation and dining, and other services such as film, arts, and entertainment, the backward correlation effects reveal a modest growth trend of about 1% in 2019 for the retail, transportation services, and accommodation and dining industries. By contrast, the film, arts, and entertainment sector exhibited a continuous decline across the four years, while retail displayed only minor fluctuations. Overall, the aggregated backward linkage effect of tourism-related industries remained relatively stable, with a slight increase in 2019 that did not exceed 1%.

An examination of sectoral rankings further clarifies these dynamics. The retail industry slipped one position in 2016 to fourth place and has since remained stable, while the transportation services sector consistently occupied the tenth position after 2017. Accommodation and dining, along with other services (notably film, arts, and entertainment), maintained ninth and tenth positions, respectively. These results suggest that among tourism-related sectors, the film, arts, and entertainment industry plays a more active role in stimulating other industries compared to retail or accommodation and dining, which have weaker backward linkage effects.

When comparing industry averages, both the transportation services and film, arts, and entertainment sectors recorded backward correlation effects slightly above the overall industrial average between 2016 and 2019, whereas retail and accommodation and dining consistently fell below average. Interestingly, the construction sector, which is indirectly influenced by tourism development, exhibited small negative growth in its backward correlation effects from 2017 to 2019. However, the decline was marginal (less than 0.5%), and by 2019 the sector rebounded with a 1.3% positive growth rate. On average, construction consistently ranked first across industries, underscoring its substantial role in driving Taiwan's overall industrial development.

In summary, the backward correlation analysis highlights that while certain tourism-related sectors—particularly film, arts, and entertainment—demonstrate notable potential in driving upstream industries, others, such as retail and accommodation, contribute less significantly. The construction sector, though not traditionally categorized as a tourism industry, plays a pivotal role as a complementary driver, amplifying the developmental impact of tourism on Taiwan's economy.

4.1.2 Forward Correlation Effect

The forward correlation effect reflects the extent to which an industry contributes to the production activities of the entire economy by providing intermediate inputs to other sectors. A higher forward correlation value indicates that an industry serves as an indispensable "basic industry," supporting the functioning and growth of numerous downstream activities. The results of this study's calculations, presented in Table 4, highlight the patterns of forward correlation effects across Taiwan's industries from 2016 to 2019.

Compared with the backward correlation effects, forward correlation values show greater fluctuations, with variations often exceeding 1%. Notably, the manufacturing sector as well as social and personal services exhibit the largest ranges, with annual changes approaching 5%. Within tourism-related industries, however, the forward correlation effects are relatively modest. The transportation services and accommodation and dining sectors show slower growth compared to other industries, while retail and film, arts, and entertainment even display negative growth trends. Although there was a slight improvement in 2019, with fluctuations under 0.1%, these changes remain minor relative to the volatility observed in other sectors.

When the forward correlation effects of all tourism-related industries are aggregated, the overall pattern closely mirrors that of backward correlation effects—annual positive and negative shifts are relatively small, and tourism sectors consistently rank lower compared to other industries. Since 2017, most tourism-related industries have remained in the lower tiers of the ranking, underscoring their limited capacity to support the broader production activities of Taiwan's economic system. An examination of industry averages further illustrates this point. The manufacturing sector consistently records very high forward correlation effects, significantly raising the overall average and highlighting its central role in Taiwan's economy. By contrast, tourism-related industries remain below the average value for all sectors, reflecting their weaker role as suppliers of intermediate goods and services. The construction sector, which is indirectly influenced by tourism development, has shown relatively strong growth in forward linkages in recent years. However, when averaged over the period 2016–2019, its forward correlation effect remains below the economy-wide average, placing it in the lower half of industry rankings.

In sum, while tourism-related industries—particularly transportation, accommodation, and entertainment—generate notable demand-side effects through backward linkages, their forward correlation effects are comparatively weaker. This indicates that the tourism sector plays a limited role in providing essential inputs to other industries, thereby constraining its ability to act as a foundational driver of Taiwan's economic system.

Table 4: The Forward Correlation Effect of Taiwan (2016~2019)

No.	Industry	Forward Correlation Effect						
		Value				Growth Rate		
		2016Y	2017Y	2018Y	2019Y	2017Y	2018Y	2019Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	1.235003	1.213159	1.207201	1.220404	-1.77%	-0.49%	1.09%
02	Traditional Manufacturing	1.103247	1.096657	1.091668	1.095021	-0.60%	-0.45%	0.31%
03	Petrochemical Industry	4.371122	4.606725	4.805830	5.014914	5.39%	4.32%	4.35%
04	Other Manufacturing	1.164625	1.2068	1.222771	1.258632	3.62%	1.32%	2.93%
05	Metal and Made from Metal	1.448855	1.45587	1.466695	1.566996	0.48%	0.74%	6.84%
06	Electronics, Machinery, and Transportation Equipment	1.205045	1.211185	1.207707	1.221997	0.51%	-0.29%	1.18%
07	Construction and Utilities	1.200485	1.192033	1.177123	1.176044	-0.70%	-1.25%	-0.09%
08	Wholesale and Retail	1.260473	1.271501	1.254189	1.263754	0.87%	-1.36%	0.76%
09	Accommodation and Dining	1.357585	1.346012	1.312854	1.317285	-0.85%	-2.46%	0.34%
10	Other Service	2.125941	2.088872	2.008542	2.004255	-1.74%	-3.85%	-0.21%
Total		16.472381	16.688814	16.754580	17.139302			
Average		1.647238	1.668881	1.675458	1.713930			

4.1.3 Total Industry Correlation Effect

The total correlation effect**,** defined as the sum of forward and backward correlation effects, provides a comprehensive measure of an industry's overall influence within the economic system. The results of this study, presented in Table 5, illustrate the combined impacts of Taiwan's industrial sectors between 2016 and 2019.

For tourism-related industries, including transportation services, catering and hotel services, and film, arts, and entertainment, the total correlation effect shows modest growth over the period, with increases of more than 0.1%. The most notable improvement occurred in 2019, when the transportation service sector recorded a growth rate of 1.14%. Despite occasional declines in individual years across these sectors, the overall trend indicates gradual growth, suggesting that Taiwan has increasingly recognized the economic importance of tourism-related industries.

The retail sector, however, presents a contrasting pattern. Its total correlation effect declined slightly from 2.5699 in 2016 to 2.5456 in 2019, reflecting a relative weakening in its systemic role. When assessed against the economy-wide average, all four tourism-related sectors consistently fall below the mean value, highlighting their limited position in Taiwan's broader industrial structure. The total correlation effect analysis reveals that while tourism-related sectors demonstrate gradual improvement and contribute to Taiwan's economic development, their overall influence remains modest compared with other industries. This finding underscores the need for targeted policies to enhance the systemic impact of tourism, particularly by strengthening linkages with non-tourism sectors and promoting higher value-added activities.

Table 5: Total Correlation Effect in Taiwan (2016~2019)

No.	Industry	Total Correlation Effect						
		Value				Growth Rate		
		2016 Y	2017 Y	2018 Y	2019 Y	2017Y	2018Y	2019Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	2.957986	2.928114	2.939931	2.974487	-1.01%	0.40%	1.18%
02	Traditional Manufacturing	2.538271	2.536569	2.502110	2.514158	-0.67%	-1.36%	0.48%
03	Petrochemical Industry	6.187819	6.458923	6.679789	6.938640	4.38%	3.42%	3.88%
04	Other Manufacturing	3.239240	3.271199	3.282695	3.345290	0.99%	0.35%	1.91%
05	Metal and Made from Metal	2.976004	3.048460	3.174636	3.484976	2.09%	4.14%	9.78%
06	Electronics, Machinery, and Transportation Equipment	2.789464	2.746647	2.709300	2.721155	-1.53%	-1.36%	0.44%
07	Construction and Utilities	2.564091	2.556605	2.535757	2.545629	-0.29%	-0.82%	0.39%
08	Wholesale and Retail	2.845267	2.867570	2.846277	2.878606	0.78%	-0.74%	1.14%
09	Accommodation and Dining	2.840849	2.832847	2.809635	2.848979	-0.28%	-0.82%	1.40%
10	Other Service	3.551023	3.515915	3.429441	3.427660	-0.99%	-2.46%	-0.05%
Total		32.490014	32.762849	32.909571	33.67958			
Average		3.2490014	3.2762849	3.2909571	3.367958			

4.1.4 Comprehensive Analysis of Related Effects

A comparison of domestic forward and backward correlation rankings from 2016 to 2019 highlights important structural differences among tourism-related industries. The retail sector, along with accommodation and dining services, consistently ranks as relatively weak in both backward and forward correlation effects, indicating limited ability to either stimulate upstream industries or support downstream production activities. By contrast, the transportation services sector occupies a middle position in both measures, suggesting a more balanced role within Taiwan's industrial system.

Notably, the film, arts, and entertainment sector, together with the construction industry, shows stronger performance in backward than in forward correlation effects. This pattern suggests that these industries are more effective at "driving" upstream development than at serving as essential suppliers of inputs. Within the tourism industry, film, arts, and entertainment stand out as particularly important for stimulating related industries, surpassing retail and accommodation in their economic impact. Meanwhile, investment in and expansion of the construction industry further "stimulate" the growth of tourism, reinforcing its function as a complementary driver of sectoral development.

4.1.5 Influence and Sensitivity

The correlation effects discussed above primarily measure the *absolute* influence of each industry on the overall economy. However, to better assess the comparative importance of industries, it is necessary to standardize both the backward and forward correlation effects. Standardization allows for the calculation of each industry's relative effect, thereby providing a clearer understanding of its role within the broader industrial structure. The results of these standardized calculations are presented in Tables 6 and 7.

Table 6: The influence of various industries in Taiwan (2016~2019)

No.	Industry	Backward Correlation Effect-Influence			
		2016 Y	2017 Y	2018 Y	2019 Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	1.091499	1.083583	1.095654	1.084237
02	Traditional Manufacturing	0.915413	0.909798	0.887764	0.877199
03	Petrochemical Industry	1.150866	1.170299	1.179511	1.189097
04	Other Manufacturing	1.314256	1.304376	1.296562	1.289808
05	Metal and Made from Metal	0.973775	1.006267	1.075016	1.185545
06	Electronics, Machinery, and Transportation Equipment	1.003719	0.970171	0.945136	0.926662
07	Construction and Utilities	0.863836	0.862196	0.855155	0.846570
08	Wholesale and Retail	0.991288	1.008465	1.002096	0.998175
09	Accommodation and Dining	0.939638	0.939446	0.942107	0.946773
10	Other Service	0.902780	0.901667	0.894346	0.879838

Table 7: The Sensitivity of Various Industries in Taiwan (2016~2019)

No.	Industry	Forward Correlation Effect-Sensitivity			
	Year	2016 Y	2017 Y	2018 Y	2019 Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	0.782366	0.766526	0.759839	0.754358
02	Traditional Manufacturing	0.698900	0.692915	0.687120	0.676856
03	Petrochemical Industry	2.769078	2.910727	3.024897	3.099827
04	Other Manufacturing	0.737782	0.762508	0.769639	0.777988
05	Metal and Made from Metal	0.917841	0.919882	0.923171	0.968594
06	Electronics, Machinery, and Transportation Equipment	0.763389	0.765279	0.760158	0.755342
07	Construction and Utilities	0.760500	0.753178	0.740907	0.726938
08	Wholesale and Retail	0.798502	0.803389	0.789415	0.781154
09	Accommodation and Dining	0.860022	0.850469	0.826340	0.814243
10	Other Service	1.346770	1.319840	1.264221	1.238873

4.2 Realized Industry-Related Effects

4.2.1 Estimation of Industry-Related Contribution Ratio

When comparing the correlation effects of the same sector across different years using the domestic product transaction table, it is possible to observe apparent changes in inter-industry linkages. However, these observed differences may not necessarily indicate substantive shifts in the structural role of an industry within the economy. Instead, they may reflect changes in measurement caused by external factors. Specifically, variations in production technology, adjustments in relative product prices, and evolving consumption patterns can all alter the recorded production structure and, in turn, the technical coefficients that underpin input–output analysis.

Such changes often lead to what Zhang and Li (2025) describe as *virtual changes* in correlation effects—that is, statistical changes that appear in the data but do not correspond to real transformations in inter-industry relationships. For example, if the relative prices of certain raw materials or intermediate goods increase, the share of these inputs in the production process may decline, thereby altering the technical coefficients. Yet this adjustment may simply be a reflection of price fluctuations rather than evidence of a genuine shift in the technology or productivity of the industry. Similarly, substitution between inputs due to short-term market conditions—such as replacing imported goods with domestic alternatives or adjusting energy sources in response to fuel price volatility—may create the illusion of structural change without fundamentally altering the industry's role in the economy.

This distinction between *real* and *virtual* changes is critical for accurate economic analysis. Real changes occur when industries experience technological upgrades, innovations in production processes, or significant alterations in the organization of supply chains. These represent lasting modifications to industrial linkages that can reshape the economy's structure. By contrast, virtual changes may disappear once relative prices stabilize, and thus they provide limited insight into long-term structural dynamics.

Recognizing this, scholars emphasize the importance of supplementing transaction table analysis with additional data sources, such as producer price indices, to better separate the effects of relative price fluctuations from genuine structural transformations. By incorporating producer price tables, it becomes possible to adjust input–output coefficients for price effects, yielding a clearer picture of whether observed changes are attributable to technological development, shifts in industrial competitiveness, or broader economic evolution. This methodological refinement enhances the reliability of linkage effect analysis, particularly for industries like tourism that are highly sensitive to external shocks, fluctuating demand, and volatile service prices. While comparing correlation effects across years offers valuable insights into industrial dynamics, the interpretation of such results must be cautious. Without distinguishing between real and virtual changes, there is a risk of overestimating or misrepresenting the importance of certain sectors

in driving economic development. By integrating producer price adjustments into the analysis, researchers can more accurately evaluate the true role of industries—such as tourism—in supporting or stimulating broader economic activity. To distinguish between these two types of changes, it is necessary to integrate data from both the domestic product transaction table and the producer price table. By accounting for price effects, researchers can separate structural changes driven by relative price fluctuations from those caused by technological or systemic shifts. Following this approach, the present study calculates the backward and forward linkage effects for 10 industries, using the producer price transaction tables published by the Chief Accounting Office of the Executive Yuan. The results of these calculations are summarized in Tables 8 and 9.

Table 8: The Backward Correlation Effect Calculated from Producer Price Transaction (2016~2019)

No.	Industry	Backward Correlation Effect of Producer Price			
		2016 Y	2017 Y	2018 Y	2019 Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	2.398588	2.408156	2.449540	2.610930
02	Traditional Manufacturing	2.228844	2.238240	2.111965	2.216657
03	Petrochemical Industry	3.322761	3.455280	3.439332	3.739715
04	Other Manufacturing	3.135669	3.200091	3.137864	3.390911
05	Metal and Made from Metal	2.590201	2.721711	2.910490	3.516529
06	Electronics, Machinery, and Transportation Equipment	1.878112	1.847474	1.775823	1.853163
07	Construction and Utilities	1.528428	1.546201	1.537077	1.588136
08	Wholesale and Retail	2.430811	2.537043	2.539124	2.643240
09	Accommodation and Dining	1.746380	1.771998	1.777647	1.907345
10	Other Service	1.585699	1.613291	1.612945	1.651192

Table 9: The Forward Correlation Effect Calculated from Producer Price Transaction (2016~2019)

No.	Industry	Forward Correlation Effect of Producer Price			
		2016 Y	2017 Y	2018 Y	2019 Y
01	Agriculture, Forestry, Fishery, and Animal Husbandry	1.383740	1.353668	1.326905	1.394746
02	Traditional Manufacturing	2.329051	2.271025	2.130897	2.323826
03	Petrochemical Industry	9.247771	10.00318	9.379245	11.4286700
04	Other Manufacturing	1.202334	1.283338	1.292358	1.393308
05	Metal and Its Products	1.634167	1.672943	1.670937	1.936303
06	Electronics, Machinery, and Transportation Equipment	1.308547	1.344326	1.318521	1.406384
07	Construction and Utilities	1.301542	1.298501	1.251636	1.289292
08	Wholesale and Retail	1.486237	1.524824	1.302100	1.533441
09	Accommodation and Dining	1.466890	1.457732	1.378826	1.434397
10	Other Service	2.424511	2.410419	2.197582	2.366104

5. Conclusion

The persistence of first-wave COVID-19 outbreaks into mid-2020 discouraged tourism worldwide, significantly reducing revenues, accelerating job losses, and triggering bankruptcies across affected economies. To revive summer tourism, countries were required to suppress viral transmission rapidly. Those facing second waves experienced similar negative impacts, though risks could be mitigated by gradually lifting restrictions in line with WHO criteria. These criteria included: (a) evidence that transmission was under control; (b) sufficient public health capacity to identify, isolate, test, trace, and quarantine cases; (c) effective protection for high-risk environments such as eldercare facilities, mental health institutions, and crowded residences; (d) preventive workplace measures including distancing, hygiene, and respiratory etiquette; (e) management of importation risks; and (f) active community participation in the transition process. In practice, coordinated government and public health efforts were essential for balancing speed and safety in exiting lockdowns, with social distancing, hygiene measures, and widespread mask-wearing playing a crucial role in minimizing renewed outbreaks: "my mask protects you, your mask protects me" (Bowen, 2010).

Against this backdrop, the present research adopts the input–output (I–O) model as its theoretical foundation to examine the linkage effects of Taiwan's tourism industry. The RAS method is applied to estimate unannounced I–O coefficient

tables for 2016–2019. Prior studies demonstrate that the RAS adjustment method yields the smallest discrepancy between estimated coefficients and actual values, making it the most reliable approach under limited research resources. Based on these adjusted data, this study evaluates both the industrial linkages and multiplier effects of Taiwan's tourism sector, with the aim of clarifying its economic position and contribution. Secondary data were obtained primarily from the Chief Accounting Office of the Executive Yuan.

For consistency with national income accounting standards, the 63-sector domestic product transaction table was consolidated into 10 categories, among which four—electronics/machinery/transportation services, wholesale and retail, catering and hotels, and other services—are directly related to tourism.

The empirical results reveal several key findings. In terms of backward co-effects, most industries showed little variation over the five years. The exceptions were the hydropower and gas sector, which grew by 7% in 2018 and 12% in 2019, and two locomotive industries—construction and manufacturing—which consistently demonstrated the strongest backward linkages, indicating their significant capacity to drive upstream development. By contrast, forward correlation effects displayed larger fluctuations. The manufacturing sector, along with financial, insurance, and real estate services, exhibited the strongest forward linkages, underscoring their central role as foundational industries that supply crucial inputs to the broader economy. Social and personal services also showed relatively high variation, with annual changes around 5%.

Within the tourism-related sectors, the analysis shows weaker overall performance. The retail industry and the catering and hotel sector ranked low in both forward and backward correlation effects, typically between 10th and 14th place, highlighting their limited capacity to stimulate or support broader industrial development. Transportation services and the film, arts, and entertainment sector performed somewhat better, with backward linkages ranking between fifth and seventh place, but their forward linkages remained weak, between seventh and tenth place. This indicates that while these sectors have some ability to drive upstream industries, their capacity to sustain downstream industries is limited.

The construction industry, though not categorized as a tourism industry per se, is heavily influenced by tourism development and demonstrates the strongest backward linkage effect across all industries. Ranking consistently first, construction emerges as a vital driver of Taiwan's overall industrial and economic growth. Thus, policies that promote tourism simultaneously stimulate construction activity, generating a multiplier effect that enhances broader economic development.

In conclusion, while Taiwan's tourism-related industries contribute modestly to industrial linkages relative to other sectors, they nevertheless play a meaningful role in stimulating complementary industries such as construction. These findings highlight the importance of aligning tourism development strategies with broader industrial policies, ensuring that investments in tourism not only generate direct benefits but also amplify growth across the wider economy.

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