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From Bonus to Onus: Taiwan's Demographic Transition and Economic Development from 1950 to 2020

Kuang-Ho Yeh,* **Guihua Ni****

* PhD candidate in International Relations at the Institute of International Relations, Nanjing University, Nanjing, Jiangsu, China, e-mail: ry1207@gmail.com

** Postdoctoral Fellow at the School of Humanities and Social Science, the Chinese University of Hong Kong, Shenzhen, Guangdong, China, e-mail: niguihua@cuhk.edu.cn

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Abstract: The driving force behind population change lies in fertility. Over the past 70 years, Taiwan has undergone a fertility transition, rapidly declining from a high peak of natural fertility levels to an ultralow rate. This transition released a substantial labour force and led to a significant shift in resource allocation, contributing to rapid economic development in the late 20th century. During the same period, Taiwan's population aging has progressed faster than that of most countries worldwide. The dependency ratio had a negative impact on economic development, making social security an important aspect of resource allocation. The changes in age structure have introduced the concepts of "demographic bonus" and "demographic onus". As a vibrant economy with a population of over 23 million, Taiwan has enjoyed the demographic bonus for more than a quarter of a century but is now facing the challenges of an aging society and declining fertility rates towards demographic onus. This article examines demographic transitions, economic performance and development in Taiwan from 1950 to 2020, elaborating on the definition, criteria, and quantitative delineation of the demographic bonus and demographic onus. It utilised population and economic statistics for a comparative analysis of the historical evolution, current situation, and prospects of the bonus and onus periods in Taiwan, providing a comprehensive narrative of its historical and empirical developments. Finally, the study underscores the complexity of balancing economic growth with demographic sustainability, emphasising the necessity for multiple policy adjustments to address the adverse effects of demographic transitions.

Keywords: demographic transition, demographic bonus, demographic onus, sub-replacement fertility, population aging

1. Introduction

During World War II, Taiwan, as a crucial colony of Japan, suffered intense Allied bombings, resulting in the destruction of over half of its industrial facilities and causing serious damage to economic productivity. After WWII, Taiwan was impacted by the Chinese Civil War, with the Kuomintang (KMT) government's high substantial military expenditures suppressing the island's economy from participating in investments. Simultaneously, to support the war effort, large amounts of resources were transported to mainland China, leading to shortages of essential goods and a sharp increase of inflation. In 1949, as the KMT regime retreated to Taiwan, over a million militants and civilians followed, causing a sudden surge in population that placed immense pressure on Taiwanese society. The economy also encountered huge challenges (Lin, 2018). In 1951, the GDP per capita of Taiwan was only $154, lower than the Philippines' $215 (adjusted to $922 using Maddison's purchasing power parity correction, still lower than Kenya in Africa with $947 at the same time). However, by the late 1980s, Taiwan had joined the ranks of the "Four Asian Tigers", with GDP per capita reaching $6,370 in 1988. By 2020, the number had reached $28,383, ranking 29th globally. Taiwanese economy had grown 184-fold over the span of 70 years, reflecting a remarkable development trajectory of rapid economic growth since the latter half of the 20th century.[1]

The transformations in Taiwan's population size and demographic structure are as remarkable as its rapid economic development. In the early 1950s, George W. Barclay predicted a population explosion for Taiwan. In his book *A Report on Taiwan's Population*, Barclay stated that with a population growth rate of 2.5%, the population of Taiwan will equal China's 450 million in 150 years (Barclay, 1954). However, the total population of Taiwan only increased from 7.98 million in 1950 to 23.57 million in 2020, far below Barclay's projection of an "explosive" increase. Regarding demographic structure, the decline in fertility rates began as early as the 1950s, which exhibited significant drops. The significant shift in fertility rates led American demographer Ronald Freedman to caution in 1986 that the Taiwanese government must carefully balance the positive and negative effects between population growth and economic development (Freedman, 1986). Additionally, the rapid decrease in mortality rates over the past decades has positioned Taiwan with the highest longevity levels globally. The process of population aging has been exceptionally swift, with the rate of aging second only to Japan in Asia.

In general, the impressive performance of Taiwan's economic growth since the 1950s has been attributed to the following macro-level factors (Mueller, 1977): 1. An ample labour supply, encompassing well-educated and skilled human resources; 2. Export-oriented industrial policies that led to the accumulation of substantial foreign exchange reserves and capital market; 3. Elevated savings rates and efficient capital allocation that facilitate investment in productive factors such as infrastructure; 4. Proficient application of advanced technologies introduced from developed countries.

These factors are closely connected to shifts in the demographic structure. Thus, this article aims to enrich the interdisciplinary understanding by examining the influence of

[1] National Statistics, R.O.C. (Taiwan). Online: https://eng.stat.gov.tw/point.asp?index=1

demographic transition on Taiwan's economic performance since the latter half of the 20th century. It particularly emphasises the analysis of age structure transformation during different periods of economic development, illustrating the linkages between the demographic bonus process and economic variables. Moreover, by utilising the integral time frame of 1950 to 2020, it presents a thorough historical and empirical narrative of the overall demographic transition, highlighting the practical and real-world significance.

2. Literature review

To date, comprehensive research exploring the interrelationship between economic growth performance and demographic transition, particularly focusing on Taiwan, compared to the abundant individual accomplishments in these two fields, remains relatively limited. Regarding the former interdisciplinary achievements, the main research from Taiwanese scholars include the work of Yu and Wang (2009) who conducted an in-depth discussion of demographic qualitative change in Taiwan. They argued that during the agricultural phase of the economy, the relationship between population and economy was primarily manifested through the ownership and utilisation of land. In contrast, during the period when industry and commerce became the mainstream, the growth and movement of population depended on the level and the geographical location of development. Tsai (2004) argued that the development model led by Japan was built on export-oriented industrialisation under state guidance. Taiwan is considered the latecomer successfully replicating the Japanese model. The East Asian "flying geese" model of economic development drove waves of foreign investment flows. On the other hand, it caused a reverse migration of labour force, with Taiwan's population movement reflecting this regional trend. Li et al. (1990) drew on theories from history, economics and sociology, supplemented by demographic data of Taiwan, to examine population growth and demographic transition in modern Taiwan. They aim to clarify the relationship between population growth and economic development in Taiwan under various socio-economic conditions across different temporal and spatial contexts. Chen and Liu (2007) conducted research on socio-economic development as the underlying mechanism for population changes, integrating various socio-economic factors to explore their impact on age-specific fertility behaviours in Taiwan. Lin et al. (2010) predicted the future trends of labour force structure in Taiwan. Their findings indicate that Taiwan's future labour force is expected to decline, while the proportion of older workers will increase. This will lead to an increase in the average age of the labour force, and the labour dependency ratio will rise. Additionally, population aging will also lead to changes in the forms of wealth possession. Peng et al. (2009) explored the relationship between changes in population age structure and the slowing momentum of consumption growth in Taiwan, summarising the interaction effects on Taiwan's consumer market from three scenarios: changes in industrial structure, the M-shaped income distribution, and the trends of decreasing birth rates and aging population. Lin et al. (2015) constructed the model to examine the reciprocal feedback effects between population and macroeconomy, predicting Taiwan's population baseline from 2012 to 2060, estimating that by 2060, the total population in Taiwan

would be 14.78 million, approximately 8.14 million less than in 2012. Taking economic factors into account, they anticipate that rapid changes in population structure will lead to more severe child and elderly care issues. Huang et al. (2019) examined the impact of population and workforce aging on Taiwan using data from 1981–2017. Based on the empirical results, they argued that accounting for policy factors, increasing the supply of the eldercare workforce and foreign manpower contribute to countering the negative impact of an aging population on national economic growth.

Contributions from scholars in mainland China and overseas include the work of Jin and Dai (2012) pointed out that since Taiwan entered the aging society in 1993, the proportion of the elderly population has demonstrated rapid growth with an average annual increase of 22%. Based on the current aging rate, it is estimated that the proportion of the elderly population in Taiwan will double in 32 years, significantly surpassing France's 115 years. Chen and Yeh (2013) utilised population-related data of Taiwan from 1981–2011 to estimate the long-term relationship between population aging and industrial structure development. They found that population aging has a lag effect on the upgrading of the industrial structure and the development of the service sector. Over the long term, the trend of population aging has a gradually increasing positive impact on the advancement of the industrial structure. Mueller (1972) carried out Taiwanese household surveys, analysing a complex set of cost and benefit considerations that have an appreciable net effect on reproductive attitudes and behaviour, after socio-economic status and demographic characteristics have been considered. Tung (1984) used the econometric model with time series data from Taiwan to simulate the economic consequences of demographic change. The results suggest that in the short term, a slow-growing population yields substantially higher income per capita than does a fast-growing population, though in the long run, the fast-growing population generates slightly better economic performance. Deaton and Paxon (1999) analysed issues of household saving, growth and aging in Taiwan. The Taiwanese patterns of high-income growth declines in fertility and increases in life expectancy all have implications for life-cycle savings. Tsai et al. (2000) reviewed the theoretical hypothesis that changing survival rates affect households' decisions on savings. They found in the case of Taiwan that prolonged life expectancy helps raise the savings rate, while higher children's survival rates reduce it. Sanchez-Romero (2009) suggested that the contribution of demography to economic growth during the demographic transition in the case of Taiwan is given by the difference between the growth rate of the number of employees and the population, while the economic growth rate relies on productivity.

3. Demographic and socio-economic transitions in Taiwan from 1950 to 2020

The following figures illustrate distinct periods and the corresponding causal connections between demographic transition and socioeconomic transformation in Taiwan from 1950 to 2020: Figure 1 depicts the alterations in total fertility rate (TFR) spanning from 1950 to 2020, accentuating pivotal population events. Figure 2 exhibits the fluctuations in GDP growth rate over the same period.

3.1. Transformation in fertility rates and economic growth from 1950 to 2020

Due to the post-war baby boom, the fertility rate in Taiwan underwent changes similar to those in Western countries. The average total fertility rate for Taiwanese women of childbearing age peaked at 7 children in the early 1950s. By the 1960s, it had decreased to 5 following the introduction of oral contraceptives and the promotion of family planning. In the 1970s, with the increased participation of women in the workforce, the number of children being born decreased even more rapidly. By 1983, the total fertility rate had dropped to the replacement level of 2.1, where the total population remains constant over generations.[2] The total fertility rate decreased by 70% over the 30-year period from 1953 to 1983.

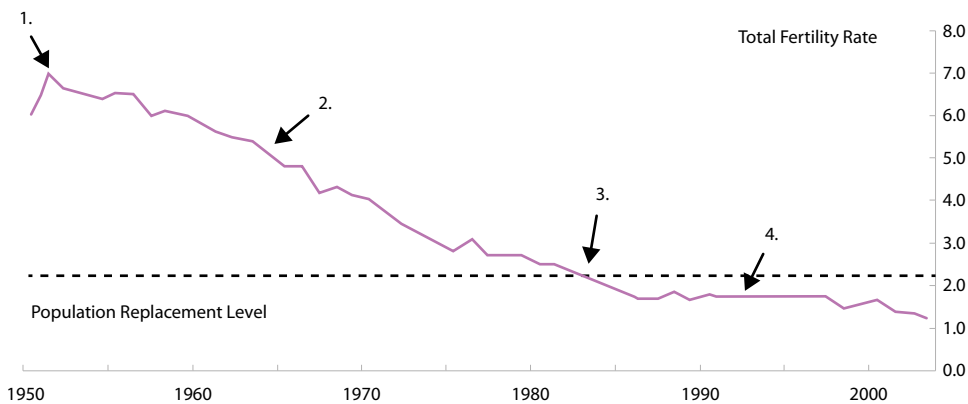

Figure 1.
Taiwan total fertility rate trend

Note: Historical traits of the total fertility rate trend curve: 1. Post-war baby boom in the early 1950s; 2. Comprehensive family planning launched in 1964; 3. Female labour force participation rate exceeds 40% in 1983; 4. Open up Taiwan to Mainland China spouses in 1992.

Source: Ministry of the Interior (Taiwan).

Mueller (1977) argued that the trend of rising and then falling fertility rates in Taiwan during the 1950s resulted in an early manifestation of growth in the labour force. The decline in fertility rates led to the growth rate of labour force faster than the overall population, providing a significant driving force for economic development through the sufficiency of labour supply. This trend also suppressed wage growth, as the abundant labour availability kept wages relatively low. The sustained low wage levels became the critical factor in the early economic growth of Taiwan from the 1950s to the 1970s. These lower wage levels shaped the competitiveness of the Island's export sector. The expansion of capital input in economy stemmed from the surplus generated by export

[2] Social Indicators Statistics. Ministry of the Interior (Taiwan), 2004. Online: www.stat.gov.tw/public/data/dgbas03/bs2/si/93%E8%AD%B0%E9%A1%8C%E5%B0%88%E8%BC%89.pdf

trade, which, in turn, raised consumer demand and social welfare levels. The continuous decline in fertility rates further reduced the dependency burden on the labour force. Besides fostering the high savings rates required for capital input, this decline also contributed to the control of wage inflationary pressures for industrial sectors. Furthermore, personal financial allocation shifted significantly away from family expenses related to raising children, accelerating the accumulation of capital and laying a solid foundation for the rapid economic growth of the following decades.

However, in the 1990s, Taiwanese authorities recognised the emerging adverse effects of the declining population trend, that the demographic policy goal was adjusted from "mitigating" population growth to "maintaining reasonable population growth". With the increase in cross-border marriages due to globalisation, the decline in fertility rates slowed slightly in the early 2000s, which remained below 1.5 births per woman. Meanwhile, economic growth decelerated after the 2000s, with an average growth rate ranging between 1% to 3%. The economic structure, overly reliant on the technology of original equipment manufacturing (OEM), made the economy highly susceptible to fluctuations in the global market. In 2001, impacted by the Dot-com bubble, the Taiwanese economy contracted by −1.4%, marking the first negative growth since 1947. The unemployment rates concurrently reached an all-time high. In 2009, under the shadow of the global financial crisis, another low point of −1.61% growth emerged. The total fertility rates for both years also began a new downward trend after remaining stable or slightly increasing in previous periods.[3]

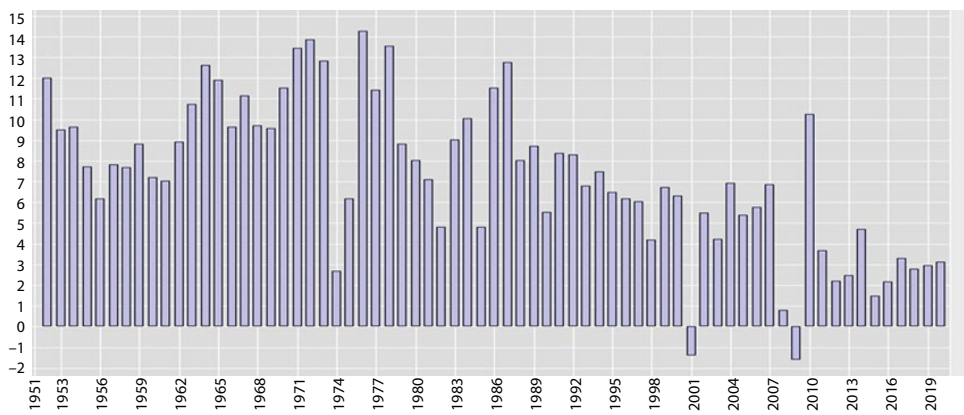

Figure 2.
Taiwan annual economic growth rate bar chart
Source: National Statistics, R.O.C. (Taiwan).

Since the 1990s, the phenomenon of stagnant real incomes has significantly impacted demographic transitions in Taiwan. The International Labour Organization (ILO) highlights common factors contributing to the decline in wage income worldwide:

[3] Population Projections for the R.O.C. (Taiwan). National Development Council. Online: https://pop-proj.ndc.gov.tw/dataSearch2.aspx?r=2&uid=2104&pid=59

technological changes, the globalisation of trade and cross-border investments, the movement of financial capital, and institutional constraints within local labour markets. These factors explain the wage stagnation in Taiwan over the past two decades. Being a highly open small-scale economy, Taiwan has inevitably experienced the effects of globalisation. The economic magnetic effect emanating from the nearby market of mainland China exacerbates this situation, as the shared culture and language facilitate the complete transplanting of Taiwanese manufacturing chains. Wage stagnation in Taiwan is more severe compared to other economies. In 2001, the substantial wages in Taiwan and South Korea were nearly identical ($1,136.44 and $1,285.14). However, by 2020, the former was still hovering around $1,400, while the latter had surged to $3,000 (Huang et al., 2014).

In recent years, the intense competition between the US and China in the realms of geopolitics and trade has profoundly impacted the Asian high-tech industrial chain. Taiwan's tech sector, especially a few semiconductor giants, has boomed from this background (Chiang, 2023). However, the rapid expansion of chip-related portions such as electronic components, and the corresponding growth in exports have bolstered impressive nominal GDP figures but masked the real income challenges faced by the majority of the workforce on the island. Behind the phenomenon of TSMC as a single company accounting for nearly one-third of the value of the Taiwanese stock market, the actual situation of consumption expenditure, which reflects the income levels of ordinary Taiwanese people, has not met expectations, exposing the reality of an unbalanced overall economic structure (Hale, 2021). Wage rigidity further worsens the decline in fertility rates. After remaining at an extremely low level of 1 to 1.2 for a long time, in 2020, the number of deaths exceeded the number of newborns for the first time, officially pushing Taiwan into the "death cross" of negative population growth. In the CIA's 2021 World Factbook report, the predicted fertility rate for Taiwan was 1.07, ranking last among 227 political entities worldwide.[4]

3.2. Evolution of mortality rates from 1950 to 2020 and the establishment of the social security system

With the continuous decline in fertility rates, the mortality rate is also showing a dramatic downward trend. Between 1950 and 2000, the average life expectancy at birth in Taiwan increased from 55.3 years to 76.5 years. By the year 2020, life expectancy at birth had risen to 78.1 years for males and 84.8 years for females, marking it one of the places with the longest lifespan in the world. Figure 3 illustrates the long-term trend in life expectancy at birth for the population of Taiwan from 1950 to 2020. The rise in average age implies that advancements in medical care have contributed to enhancing the survival rate of the elderly. Beyond the supply and demand of medical services, the most effective way to cope with aging is to proactively plan for post-retirement needs.

[4] The World Factbook 2021–2022. Central Intelligence Agency, 2021. Online: www.cia.gov/the-world-factbook/field/total-fertility-rate/country-comparison

With these considerations, Taiwanese authorities have promoted the National Health Insurance (NHI), National Pension Insurance, and the long-term care insurance progressively since the mid-1990s. This endeavour has constructed a comprehensive social security system encompassing medical, socio-economic and caregiving dimensions.

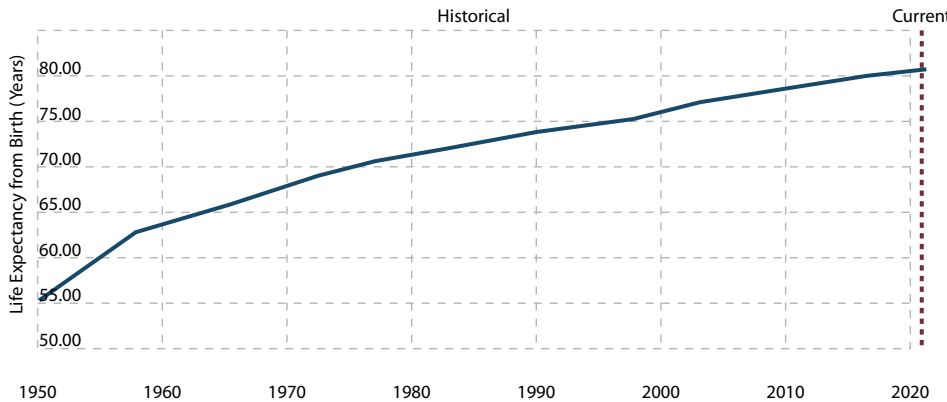

Figure 3.
Taiwan population life expectancy trend
Source: Taiwan Life Expectancy 1950–2024 [Data set], Macrotrends.net. Online: www.macrotrends.net/countries/TWN/taiwan/life-expectancy

The National Health Insurance (NHI) implemented in 1995 provides health coverage for all residents across the island through mandatory medical insurance. The NHI contributes to extending the average life expectancy, particularly by reducing occurrences of medical avoidable mortality. A decade after its implementation, life expectancy increased by 2.6 years for males and 3.0 years for females, surpassing the increases observed prior to its implementation (1.4 and 2.3 years respectively). The NHI has also enhanced the equity of medical care for the vulnerable groups. Empirical evidence indicates that after the introduction of the NHI, the utilisation rates for outpatient and inpatient services among elderly individuals lacking other health insurance increased by 27.97% and 12.5%, which is in stark contrast to the much lower increase rates of 13.34% and 1.69% among the well-insured elderly. In 2008, Taiwan began implementing the National Pension Insurance to ensure individuals aged 25 to 65 who had not participated in other social insurance programs would maintain a basic living standard in their old age, thus safeguarding the economic security of the elderly population. From 1950 to 2020, the proportion of social security system expenditures in the public finance sector increased from 0.09% to 25.2%, marking a significant progress.[5]

Figure 4 depicts Taiwan's trajectory toward becoming an aging society in 1993, progressing to an aged society in 2018, and anticipated to evolve into a super aged society

[5] The data of 1950 is in the Central Government Expenditure Final Accounts (1950). The data of 2020 can be found at the Analysis of Central Government Total Budget Expenditure (2020). National Statistics, R.O.C. (Taiwan).

by 2025, driven by a steep decline in fertility and mortality rates. The percentage of the population aged 65 and above surged from approximately 2% in 1950 to 16% in 2020, while the proportion of those aged 0 to 14 decreased from 40% to 12.5% during the same period. The aging index (the ratio of the elderly population to the youth population) rose remarkably from 5 to 128 over the course of 70 years.

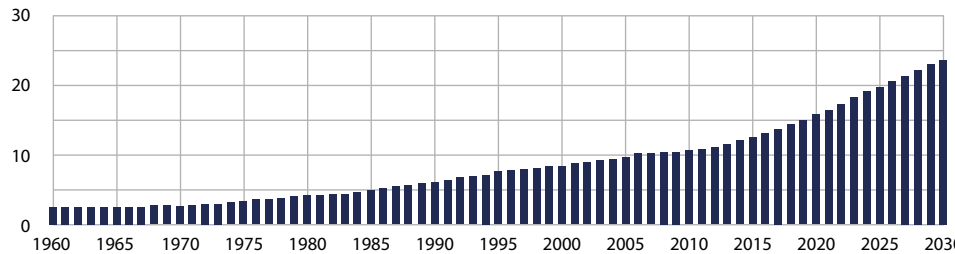

Figure 4.
Taiwan elderly population percentage trend
Source: National Development Council (Taiwan).

The total dependency ratio in Taiwan displayed a zigzag pattern from 1950 to 2020 (Figure 5). In the 1950s and 1960s, a substantial increase in the young population due to the baby boom resulted in the total dependency ratio peaking at 94.05 in 1962. Subsequently, it began to decrease steeply with the decline in fertility rates, reaching 34.74 by 2013. The continuous growth of the elderly population began to exert a dominant influence on the total dependency ratio at the same time. After 2013, the total dependency ratio started to rise again, and the child dependency ratio and the old-age dependency ratio intersected in 2017. From then on, the old-age dependency ratio became the determining factor of the total dependency ratio.

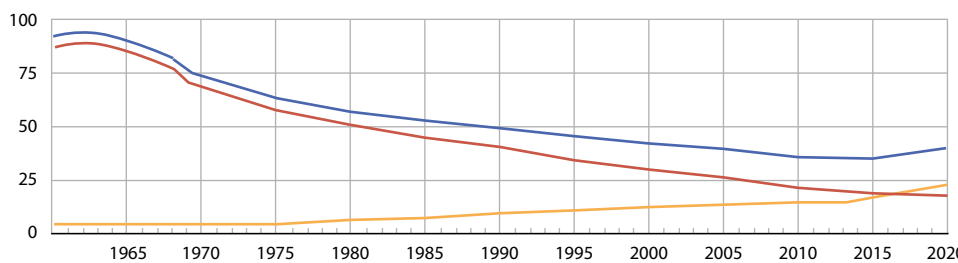

Figure 5.
Total (blue curve), youth (red) and elderly (orange) dependency ratio trend
Note: The child dependency ratio refers to the number of youth population supported by every hundred working-age population, while the old-age dependency ratio refers to the number of the elderly supported by the same population group.
Source: National Development Council (Taiwan).

4. "Demographic bonus" and "demographic onus": Macro-level assessment of the impact of demographic transition on economic development

Taiwan completed the demographic transition from high birth and death rates to low rates after 1983. Amid the slowdown in population growth, there was an expansion of the workforce, leading to a greater share of economic resources transmitted toward it. The shift reaped economic benefits brought about by a process spanning several decades from the mid-1960s (Chang & Lee, 2001). This article adopts a macro-level assessment approach, utilising historical data and quantitative methods to evaluate the impact of demographic transition phases on Taiwan's economy. It integrates a comparative analysis of different demographic stages and their respective economic impacts, thereby providing the perspective on the relationship between population dynamics and economic development.

"Demographic Bonus" interprets the time period when the age structure of the population enters a "harvest" phase, and a larger proportion of the labour force population plays a catalytic role in economic growth. According to the basic quantitative definition by the United Nations Population Fund (UNFPA), demographic bonus refers to the working-age population (ages 15–64) accounting for more than 66.7% of the total population, as the dependency ratio being lower than 50%. Meanwhile, the "demographic window" (UNFPA, 2010) signaling the entrance into the period of demographic bonus opens. Demographic bonus and its reverse function of "Demographic Onus"– the sustained population decline during the demographic bonus phase ultimately results in the shrunk working-age population bearing a significant burden of the social security and welfare costs for the larger non-working population, constitute the entire process and the overarching theory of "demographic dividend". The theory originally proposed by David E. Bloom and Jeffrey G. Williamson (1998), is based on changes in the proportions of population within the three age groups, reflecting the population structure and labour force required for economic development. Bloom and Williamson argued that a significant portion of the economic growth in the "Four Asian Tigers" during the 1960s to 1990s could be attributed to the transitions of demographic bonus. Generally, during the transition to low fertility and mortality rates, the natural increase in a country's labour force will create the so-called "demographic window". In this period, the dependency ratio will be low, and the mature cohort of the labour force has the capability to enhance the country's economic prosperity (Misra, 2015).

The demographic bonus is distributed through various interconnected mechanisms that can shape the overall circulation toward final economic growth, as depicted in Figure 6. In the context of demographic transition, the population structure shifts towards a larger proportion of the working-age population, which increases as the dependent population decreases due to policy intervention. Consequently, three feedback effects of the demographic bonus emerge: a release in labour supply, an increase in savings, and an improvement in the quality of human capital (Bloom et al., 2003). Firstly, the increased labour supply helps suppress wage costs, enhancing industrial competitiveness. The reduced

caregiving demands free up the labour force, especially among women, further augmenting the labour supply. Secondly, the change in population structure leads to a decrease in dependency expenditures. Since the consumption of the dependent population generally exceeds their production, the increased working-age population is motivated to save for their future retirement owing to the longer life expectancy. This raises the savings rate, thereby promoting domestic investment and contributing to the nation's social and financial growth. Lastly, the trend of the population structure shift is favourable for national, corporate and familial investments in human capital. The outcome of investing in one's own and the next generation's education and professional training is the substantial enhancement of economic productivity (Chen, 2016).

After amassing nearly four decades of demographic development momentum, Taiwan entered the demographic window in 1990, as the age structure of the population transitioned into the demographic bonus. Nevertheless, entering the 21st century, economic growth has shown a decline compared to the past, suggesting that the demographic bonus is gradually diminishing. This implies that the Taiwanese economy is on the verge of transitioning from a stage that reaps benefits from the demographic bonus to a phase that bears the burden of another continuous transition, which is referred to as the negative dividend stage of demographic onus. The following integrates and argues for the complete theory of demographic dividend, combining the development cases of Taiwan with different perspectives of representative scholars.

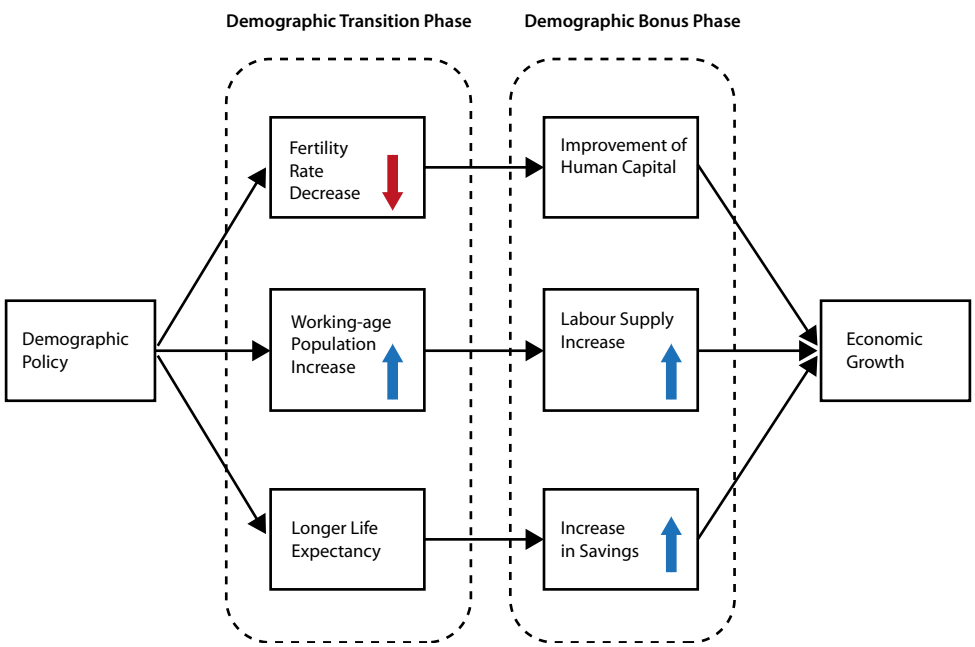

Figure 6.
The mechanism of demographic bonus loop
Source: Compiled by the authors.

4.1. Demographic bonus and economic development

Table 1 presents a combination of Taiwan's labour force participation rate, dependency ratio, and economic growth rate from 1990 to 2020, following the onset of the demographic bonus phase. The objective is to assess the impact of the declining fertility rate on economic development throughout the entire time span. The five-year average value (calculated as 6 years for 1990–1995) dilutes the impacts of individual years (2001, 2009, 2010) with extreme fluctuations in economic performance. The outcomes depicted in Table 1 reveal that Taiwan encountered a decline in economic growth after 2000, which did not seem to reflect the apparent positive impact of the demographic bonus on economic development. However, as mentioned earlier, the decline in Taiwan's economic growth rate indeed reflects the economy entering a transitional phase, influenced by multiple exogenous variables. At this juncture, the phenomenon of the demographic bonus is better interpreted as a "brake pad" effect exerted by demographic factors during economic recessions.

Table 1.
Labour force participation rate, dependency ratio and economic growth rate from 1990 to 2020

	Labour Force Participation Rate (%)	**Dependency Ratio (%)**	**Economic Growth Rate (%)**
1990–1995	67.64	47.87	7.17
1996–2000	69.70	43.48	5.89
2001–2005	70.93	40.99	4.13
2006–2010	72.68	37.61	4.41
2011–2015	74.07	35.01	2.91
2016–2020	72.46	38.02	2.87

Source: Ministry of Labour (Taiwan).

On the other hand, Ogawa et al. (2005), Wang and Mason (2006) define the demographic bonus as the period during which the growth rate of GDP per capita for the entire population exceeds the growth rate of GDP per worker employed. By broadening the concept of demographic bonus from a simplified change in age structure to a connection with economy, it highlights the core impetus of demographic bonus – the contribution to overall societal output resulting from the changes in the labour force structure. In contrast, the demographic onus exhibits a reverse pattern.

In accordance with the demographic bonus definition of Table 1, Table 2 calculates the five-year statistics for the growth rate of GDP per capita and the growth rate of GDP per worker starting from 1990. It is evident that in the initial five intervals from 1990 to 2015, the growth rate of GDP per capita exceeded that of GDP per worker. The results for output per capita and output per worker validate that the demographic bonus's impact on economic growth remained consistently active between 1990 and 2015. However, starting in 2016, the growth rate of GDP per capita fell below that of GDP per worker,

marking the inflection point. The underlying reason for this shift is that the labour force began to decline during this period (–1.3%), while the total population continued to rise. Consequently, the driving force of labour output contributing to the overall societal output significantly weakened.

Table 2.
GDP per capita, GDP per worker and the periodic growth rates in Taiwan from 1990 to 2020

	GDP (millions of USD)	**GDP Per Capita (1)**	**GDP Per Worker (2)**	**Total Population (per thousand)**	**Total Labour Force (per thousand)**	**Growth Rate of (1)**	**Growth Rate of (2)**
1990–1995	224,435	10,768	15,882	20,890	14,131	N/A	N/A
1996–2000	302,053	13,839	19,774	21,913	15,275	28.5	24.5
2001–2005	329,006	14,584	20,526	22,598	16,029	5.4	3.8
2006–2010	408,858	17,780	24,425	23,031	16,739	21.9	19.0
2011–2015	512,451	21,958	29,606	23,368	17,309	23.5	21.2
2016–2020	604,835	25,664	35,410	23,573	17,081	16.9	19.6

Note: The gray highlighted cells indicate the stages where the growth rate of GDP per capita was lower than that of GDP per worker.

Source: National Statistics, R.O.C. (Taiwan).

4.2. Degree of contribution of the demographic bonus to Taiwan's economic development

Chen Youhua (2008) formulated the model to calculate the quantitative contribution rate of the demographic bonus to economic growth as follows:

$$\mathrm{GDP}_t^s = \frac{\mathrm{GDP}_t}{\mathrm{L}_t} \times \frac{\mathrm{L}_s}{\mathrm{P}_s} \times \mathrm{P}_t (1)$$

$$\text{GDP contribution rate of demographic transitional factors} = \frac{\mathrm{GDP}_t - \mathrm{GDP}_t^s}{\mathrm{GDP}_t} \times 100\% \ (2)$$

In Formula (1), L and P represent the labour force and total population respectively. GDP_t, Lt, and Pt are values for the statistical year, while L_s and P_s are the labour force and total population to the reference population. GDP_t is the actual GDP for year t under the influence of demographic transition, while GDPs t represents the theoretical GDP for year t excluding the demographic impact. The contribution rate of demographic transitions to GDP is illustrated in Formula (2). The positive rate signifies the demographic bonus phase, while the negative rate indicates the demographic onus stage.

Table 3 illustrates the actual contribution of demographic transition to GDP growth between 1990 and 2020. Nearly 3% of GDP growth in the years 1996–2000 was attributed to the demographic bonus. However, during the years 2016–2020, the contribution rate turned negative, suggesting that the demographic bonus was approaching its end. This aligns with the economic impact of a declining labour force, as inferred from Table 2. It is confirmed that after going through different quantitative models, international scholars converge in their deduction processes regarding the relative change in the labour force population as the core variable in the demographic bonus loop. Such theoretical consistency reinforces the applicability of demographic bonus in explaining its impact on the economic aspect.

The following further deduces an analytical hypothesis based on the descriptive statistical verification of the existing theories mentioned above: GDP = F(W). According to the data series of five-year statistics in Table 2, GDP represents the per capita output for different time periods, while W denotes the output level of the labour force at the same period. The empirical model is as follows: $\ln GDP = \alpha_0 + \alpha_1 \ln W$. When regression analysis was conducted using data from the period of demographic bonus from 1990 to 2015, it yielded the results: $\ln GDP = -1.696 + 1.13 \ln W$, with the P-value less than 0.05, indicating statistical significance. Additionally, $R^2 = 0.9993$, Adj-$R^2 = 0.9990$, indicating a proper goodness of fit of the model. The coefficient of the study variable is 1.13, indicating a positive correlation with the explained variable, and as the coefficient is greater than 1, it suggests a multiplier effect during the demographic bonus period driving the economy. However, when data from the period of demographic onus starting from 2016 are included, the coefficient decreases to 1.06, indicating a decline in the driving effect.

Table 3.
Contribution of demographic bonus to economic growth in Taiwan

	GDPt (millions of USD)	**GDPst (millions of USD)**	**Contribution Rate of Demographic Bonus (%)**	**Pt (per thousand)**	**Lt (per thousand)**	**Ls/Ps**	**Pt/Lt**
1985–1989	105,193	N/A	N/A	19,732	13,023	N/A	N/A
1990–1995	224,435	219,228	2.3	20,890	14,131	0.66	1.48
1996–2000	302,053	293,716	2.8	21,913	15,275	0.68	1.43
2001–2005	329,006	324,729	1.3	22,598	16,029	0.70	1.41
2006–2010	408,858	400,599	2	23,031	16,739	0.71	1.38
2011–2015	512,451	505,020	1.5	23,368	17,309	0.73	1.35
2016–2020	604,835	617,658	–2.1	23,573	17,081	0.74	1.38

Note: The gray highlighted cells indicate the declining trend in the labour force, and the negative contribution rate to GDP growth (–2.1%).

Source: National Statistics, R.O.C. (Taiwan).

4.3. The arrival of the demographic onus

The formation and persistence of the demographic bonus have provided a certain degree of support for Taiwan's economic development. The decline in the young population has led to an increased proportion of the labour force, thus extending the demographic bonus. However, the accelerating growth of the elderly population has consistently outpaced other age groups, making population aging the primary factor driving the end of the bonus period. Notably, the labour force that fuelled economic development during its peak began to retire after the 2010s, leading to widening gaps between variables. Estimated according to the UNFPA standard, Taiwan is projected to transition from the demographic bonus to the demographic onus stage by 2027. Based on calculations using the academic definitions, this article concludes that Taiwan already displayed signs of demographic onus during 2016–2020. Table 4 combined with predicted population and economic growth values for 2021–2025 in Taiwan,[6] computes that the growth rate of GDP per capita during this period consistently remains lower than the growth rate of GDP per worker, given the negative contribution rate. This not only aligns with the foundational definition, but also underscores the more sensitive and realistic interconnected effects between demography and economy. As time progresses, upon reaching the static age structure that formally signifies the demographic onus, the disparities between variables will further expand.

Table 4.
Economic performances synthesised different demographic bonus/onus definitions

	Labour Force Participation Rate (%)	Dependency Ratio (%)	GDP	GDP Per Capita	GDP Per Worker	Growth Rate of GDP Per Capita (%)	Growth Rate of GDP Per Worker (%)	Contribution Rate of Demographic Bonus (%)
2011–2015	74.07	35.01	512,451	21,958	29,606	23.5	21.2	1.5
2016–2020	72.46	38.02	604,835	25,664	35,410	16.9	19.6	–2.1
2021–2025*	69.54	43.80	684,971	29,158	41,922	13.6	18.3	–3.7

Note: 1. The gray highlighted cells signify the GDP contribution rate resulting from demographic transition. 2. *Denotes GDP forecast for 2021–2025 based on IMF "World Economic Outlook Database". Online: www.imf.org/en/Publications/WEO/weo-database/2021/October

Source: National Statistics, R.O.C. (Taiwan).

[6] Population Projections for the R.O.C. (Taiwan). National Development Council. Online: https://pop-proj.ndc.gov.tw/dataSearch2.aspx?r=2&uid=2104&pid=59

5. Prospects and challenges of demographic development in Taiwan: The coexistence of population aging and sub-replacement fertility

Regarding future economic growth which is gradually slowing down in Taiwan, the impact of demographic onus is undoubtedly a serious challenge. Demographic onus arises from a diminishing proportion of the labour force and an elevated dependency ratio, encompassing two crucial endogenous driving forces: population aging and sub-replacement fertility.

5.1. Population aging

Many countries, particularly developed ones, face similar challenges of population aging to Taiwan. As the country experiencing the fastest population aging globally, Japan has witnessed a continuous and rapid increase in the size and proportion of its elderly population over more than half a century. The total population aged 65 and above has surged from around 5.4 million in 1960 to over 37 million in 2020, marking an increase of 6.9 times over 60 years. In terms of demographic structure, Japan has long surpassed the benchmark of a super-aged society. In 2020, the population aged 65 and above constituted approximately 30% (29.58%) of the total population.[7] Population aging inevitably accompanies the increased utilisation of medical resources, impacting Japan's social security system, particularly healthcare, long-term care and pensions, along with the local economies (Suzuki, 2023). In Taiwan, the average life expectancy at birth increased from 55.3 years in 1950 to 81.3 years in 2020, indicating the impending transition into a super-aged society (the proportion of the elderly population surpasses 20%). The total population of individuals aged 65 and above has steadily risen from around 0.16 million in 1950 to 1.92 million in 2000, and further to 3.79 million in 2020. Projections suggest it will reach 4.7 million by the year 2025. Moreover, there is a notable gender disparity in mortality rates during the elderly stage, with females increasingly dominating the population. The rapid feminisation of the elderly demographic suggests that the number of elderly widows will significantly increase in the future. The median age of the population in Taiwan has sharply risen due to the aging trend, going from 17.7 years in 1960 to 42.8 years in 2020, indicating that more than half of the population has entered middle age.[8]

A shortage of labour supply is a direct consequence of population aging on economic development. Population aging accelerates the aging of the labour force, resulting not only in a current reduction in the labour force, but also indicating a continuous decline in future supply. This reduction in the labour force affects productivity, subsequently

[7] Population ages 65 and above (% of total population) – Japan. World Bank. Online: https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS?locations=JP

[8] Population Projections for the R.O.C. (Taiwan). National Development Council. Online: https://pop-proj.ndc.gov.tw/dataSearch2.aspx?r=2&uid=2104&pid=59

impacting economic growth. According to the definition, the demographic bonus effect, driven by the growth of GDP per worker leading to the growth of GDP per capita, will gradually shift towards a reverse model of demographic onus.

The most serious impact of population aging is the increased financial burden on the public sector, along with a crowding-out effect on other policy budgets. Regarding medical insurance, population aging leads to a higher utilisation of medical resources in the island. Between 2000 and 2018, the proportion of medical utilisation by the population aged 65 and above rose from 28.8% to 38.2%, with expenditures growing by over 30%. In 2020, National Health Insurance expenditures exceeded 750 billion New Taiwan Dollars (1 NTD is approximately equal to 0.03 USD), with the elderly population's expenditures being 3.5 times that of the average population, imposing immense pressure on the healthcare system.[9] Between 1951 and 1971, the elderly dependency ratio in Taiwan hovered around 5%, meaning that every 20 working-age individual supported an elderly person (Department of Population Affairs, Ministry of the Interior [Taiwan], 2013). However, by 2020, the dependency ratio had surged to 23%, implying that every 4.3 working-age individual were required to support a single elderly person. According to government estimates, by 2025, as Taiwan enters a super-aged society with the population born during the baby boom retiring, the elderly dependency ratio will approach 30%, requiring the support of every 3.3 individual for one elderly person.

Meanwhile, the number of individuals with dementia and disabilities within the elderly population are increasing. In 2020, there were approximately 760,000 individuals with disabilities requiring long-term care. It is estimated that by the year 2026, this number will escalate to one million, reflecting a 30% increase (Department of Population Affairs, Ministry of the Interior [Taiwan], 2013). On the other hand, influenced by the traditional mindset, family units primarily serve as caregivers for disabled individuals. In terms of provision, taking care of one disabled member requires up to 9.9 years, incurring average costs of up to 4.85 million NTD (Chen, 2016). The long-term care of the elderly population has become a heavy burden on both working-age population and families. The proportion of females leaving jobs due to caregiving responsibilities has significantly increased. For married couples in their prime working years, the conflict between career competition and caregiving responsibilities has further led to a displacement effect on fertility, resulting in an irreversible transition.

5.2. Sub-replacement fertility

The concept of sub-replacement fertility was initially introduced by the Japanese Government in the White Paper on the National Lifestyle in 1992 (Cabinet Office, 2004). It refers to the trend in which the number of newborns continues to decrease amid an overall decline in the fertility rate among childbearing-aged women. Sub-replacement fertility has significant impacts on various aspects of society and economic development, constituting challenges faced by developed countries worldwide.

[9] National Statistics, R.O.C. (Taiwan). Online: https://eng.stat.gov.tw/point.asp?index=1

The declining trend unveiled by sub-replacement fertility lacks standardised indicators. For instance, the post-war baby boom in Japan was extremely short, lasting only from 1947 to 1949. After this brief period, the fertility rate started to decline sharply. Over the decade from 1947 to 1957, the total fertility rate dropped by over 50%, with the average number of children born per woman decreasing from 4.54 to 2.04 (Ogawa et al., 2005). By 1975, the fertility rate had fallen below 2.0, and in 1989, Japan hit its historically lowest rate at a "shocking 1.57". Demographic decline became a prominent public issue in Japanese society. By 2003, the total fertility rate had dropped to 1.29, earning Japan the label of a "ultra-low fertility" country (Tsuya, 2017). In Taiwan, the process of entering sub-replacement fertility involved surpassing several statistical benchmarks. In 1983, the total fertility rate first dropped below the replacement level. The total fertility rate was 1.23 in 2003, lower than that of Japan, earning it a place among the United Nations' ranks of the ten polities with the lowest fertility rates. Starting from 2019, Taiwan's total fertility rate has become the lowest in the world.

Sub-replacement fertility and population aging mutually reinforce each other in a negative spiral during demographic transition, displaying a seesaw effect where one end descends while the other ascends. This phenomenon is illustrated by the curve of the overall dependency ratio of the young and the elderly (Figure 5). The burden first decreases and then increases over time. In Taiwan, the pivotal moment in the dependency ratio occurred in 2014. Projections indicate that by 2050, every 1.5 working-age individual will support one elderly person, marking a threefold increase compared to the present. This burden is reflected in the financing of social security systems. Calculations based on the concealed liabilities of the social security systems reveal a staggering 18 trillion NTD currently. This indicates that by 2020, each of the 2.96 million ndividual under 14 years old in Taiwan would carry a liability of over 6 million NTD in these funds, highlighting the severe reality of the intensified pressure on the young generation due to the combined effects of sub-replacement fertility and population aging (Wang, 2017).

Frank Schirrmacher argued that sub-replacement fertility has far-reaching implications for human society. Families, which serve as the foundation of social cohesion, would be the first to endure the impact of the transition. In a context where family sizes are shrinking, the absence of future generations would impede the transmission of life values such as accomplishments and happiness. With the perpetuation of family eroding, younger generations either opt not to have children or have only one child, thereby fostering intergenerational effects. Consequently, existing social networks and orders are exposed to the risk of collapse (Schirrmacher, 2008). Chang and Song (2010) describe "compressed modernity" as the occurrence of contemporary economic, political and cultural changes in an extremely condensed manner across both time and space. The dynamic coexistence of mutually disparate historical and social development elements leads to the creation and reconfiguration of a highly complex and fluid social system. The practice of compressed modernity is evidenced in the evolving values of family and marriage in Taiwan.

5.3. Demographic transition and value change

The main factors influencing the decline in fertility rates in Taiwan from 1950 to 2020 have varied over time. In the 1950s, the decrease in the total fertility rate stemmed from a decline in the marriage fertility rate, especially a significant reduction in the probability of giving birth to three or more children. From the 1980s, the increasing age at first marriage became the primary factor for the decline in fertility rates. Higher education and increased female employment escalated the opportunity costs of childbearing. After 2000, the elevated average age for giving birth to the first child emerged as the dominant factor. The combination of stagnant wages and a prevailing pessimistic economic outlook among the childbearing-aged population greatly impacted decisions regarding fertility. In 2020, the average age of first marriage for women in Taiwan was 30.3 years, while the age for giving birth to the first child was 31.1 years, significantly higher than in most Asian countries (Gender Equality Committee, 2020).

The values associated with marriage and childbearing, which inherently drive changes in the fertility rate, have undergone significant transformations over the past 70 years. In studies addressing the ultra-low fertility rates in East Asia, Gavin Jones pointed out a deeper underlying concern behind low fertility rates, namely the atmosphere of "flight from marriage". Young people choose to evade marriage due to the challenging surroundings of establishing households (Jones, 2005). He argues that East Asian cultures still retain marriage and childbearing values of "selecting marriage", exemplified by the prevalent concept of "hypergamy", where individuals and their families seek upward social mobility through marriage. In this context, involuntary singleness will become more widespread in the era of sub-replacement fertility, leading to serious consequences of childlessness. Furthermore, macro-socioeconomic determinants such as job insecurity, work-family conflicts, the desire for high-quality offspring, and the insufficiency of government policy support have collectively reduced the willingness of married couples to raise children (Jones, 2008). On the other hand, the report from Taiwan's Ministry of Health and Welfare on Elderly Conditions indicates that approximately two-thirds of the population aged 65 and above reside in two-generation, three-generation, or even four-generation households. Compared to other aging countries, Taiwan demonstrates a relatively distinctive strength in family support, suggesting that social norms concerning family caregiving responsibilities and the traditional cultural emphasis on filial piety still exert influences over the care provided to the elderly population (Ministry of Health and Welfare, 2017).

6. Conclusion

Between 1950 and 1970, Taiwan relied on resources for agricultural and industrial development from the United States, providing an annual average of $100 million in assistance known as the US Aid. The reduction of dependency on new births emerged as an effective medium for capital accumulation and growth, aiming to accelerate Taiwan's self-sufficiency, alleviate the burden of US Aid, and transform Taiwan into

a labour hub for the US capital in East Asia. In 1959, Jiang Menglin, Director-General of the Sino-American Joint Commission on Rural Reconstruction (JCRR), wrote the famous essay, *Let's Confront the Urgent Issue of Taiwan's Population,* marking the inception of family planning and birth control policies on the island. The sustained decline in Taiwan's total fertility rate obviously contributed to the subsequent economic take-off (Tsai, 2007). The demographic bonus that began after 1990 was the final stage where demographic factors positively impacted economic growth. As shown in this article, the bonus stage ceased to exist by the 2020s. Conversely, the decline in fertility rates is a major cause of rapid population aging. In the early 1990s, Taiwan shifted from the traditional focus on birth control in family planning to the New Family Plan, prioritising the enhancement of population quality. Simultaneously, efforts were made to implement welfare policies to alleviate the challenges of marriage and raising children. These policies include instruments such as flexible working hours, paid leave, and childcare services that aim to improve the quality of family life. However, countering the forces leading to low fertility rates need to be assessed within the broader context of family policies, requiring the adjustments of entrenched cultural, institutional and familial arrangements, all of which are challenging to achieve (Jones & Hamid, 2015). Despite these endeavours, fertility rates have continued to decline, and population aging has become an irreversible structural transformation.

In addition to interventions targeting actual fertility behaviour, Taiwan is also committed to devising policies to increase the labour force and to minimise its contraction. Policy tools include extending working life, raising female labour force participation rate (LFPR) and enabling more workers to move from part-time employment into full-time employment, to address the adverse consequences of demographic onus (Jones, 2019). Besides, the rigid standard defining the age of elderly population has led to increasing adaptation challenges in the labour market and the functioning of social security systems. To address these problems, several aging countries have redefined the age criterion for classifying the elderly population. For example, Japan passed the Law Concerning Stable Employment of Older Persons in 2021, officially extending the legal retirement age for employees to 70. In the case of Taiwan, if the age definition of the elderly population is raised from the current 65 to 70, the adjusted proportion of the elderly population will remain below 20% over the next 15 years. This change could potentially sustain the demographic bonus phase until 2041.[10] Certainly, the issue of redefining the age of the elderly population is a considerable societal engineering that necessitates political leadership, professional expertise, widespread consensus and collaboration across economic sectors. Balancing the overall governance sustainability of the economic-social system will be a major goal and challenge for Taiwan's demographic policy in the future.

In rapidly aging economies, the gradual shortage and changing age structure of the labour force will drive the need for enhancements in individual productivity and automation. Given the global industrial trend towards innovative technologies such as artificial intelligence and Taiwan's reliance on the ICT industry, further developing

[10] Population Projections for the R.O.C. (Taiwan). National Development Council. Online: https://pop-proj.ndc.gov.tw/dataSearch2.aspx?r=2&uid=2104&pid=59

the demographic bonus – the demographic quality divide – is crucial for Taiwan's future demographic transition and economic development. The primary feature of the demographic quality dividend is the steadily increasing ratio of labour capital investment to the working-age population (Mason et al., 2016). This evolution shifts the focus of the labour factor from mere quantitative changes to significant qualitative leaps, promoting a technology and innovation-driven "intensive" perspective on demographic transition (Wang, 2021). Enhancements in the quality and productivity of the labour force can, to some extent, mitigate the impact of its relative numerical decline. Based on Figure 6, the increase in savings among the working-age population has promoted substantial investments in human capital, primarily through educational expenditure. Such capital deepening is the core driving force behind the formation of the demographic quality dividend. By raising the knowledge and skill levels of the educated population, the quality of the labour force can be enhanced, thus flourishing the labour force mobility (Zhou et al., 2023). This is conducive to the market-oriented allocation of labour resources and alleviates the lurch of "technological unemployment" (Jafrin & Masud, 2020) caused by the application of updated technologies in the workplace, leading to an improvement in the labour employment rate, including the elderly labour population. In recent years, the Taiwanese government has enacted the core strategic industries plan and policies strengthening the cultivation of digital talents, thereby optimising the demographic quality dividend. This article reveals that the early policies that "served" economic development have generated new demographic outcomes due to economic growth, triggering a new phase of adjustment and planning. The interplay between demographic transition and economic development has evolved into an ongoing feedback loop, constituting a mutually reinforcing cycle of policy dynamics, which is also a rich field for future researchers to delve in further empirical studies of Taiwan.

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