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COMPARATIVE ASSESSMENT OF GROWTH SUSTAINABILITY BETWEEN CHINA, JAPAN, REPUBLIC OF KOREA, AND TAIWAN: 2000 TO 2010

The article is the presentation of calculated results based on time series data for testing the original and experimental inequation developed on the basis of a broader research. This article focuses on testing the sustainable growth of China, Japan, Republic of Korea and Taiwan.

Keywords: *growth sustainability; China; Japan; Republic of Korea; Taiwan; technological progress; welfare; economic growth.*

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ПОРІВНЯЛЬНИЙ АНАЛІЗ СТІЙКОСТІ ЗРОСТАННЯ КИТАЮ, ЯПОНІЇ, РЕСПУБЛІКИ КОРЕЯ ТА ТАЙВАНЮ З 2000 ПО 2010 РІК

У статті представлено результати даних часового ряду для тестування оригінальної та експериментальної нерівності, що спирається на базу масштабного дослідження. Тестування проведено відносно стійкого розвитку Китаю, Японії, Республіки Корея та Тайваню.

Ключові слова: *стійке зростання; Китай; Японія; Республіка Корея; Тайвань; технологічний прогрес; добробут; економічне зростання.*

Форм. 1. Рис. 6. Табл. 4. Літ. 45.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ УСТОЙЧИВОСТИ РОСТА КИТАЯ, ЯПОНИИ, РЕСПУБЛИКИ КОРЕЯ И ТАЙВАНЯ С 2000 ПО 2010 ГОД

В статье представлены результаты данных временного ряда для тестирования оригинального и экспериментального неравенства, основанного на базе обширного исследования. Тестирование проведено для устойчивого развития Китая, Японии, Республики Корея и Тайваня.

Ключевые слова: *устойчивый рост; Китай; Япония; Республика Корея; Тайвань; технологический прогресс; благополучие; экономический рост.*

Introduction. Growth sustainability is defined as a balanced development that reflects the needs of a current generation, but does deprive future generations from progress and the ability to satisfy their own needs. The basic principle of sustainability is fair and equal distribution of resources (technological, financial etc.) not only by the current generation but also by further generations.

Generally, sustainability might be evaluated through different measures, especially when comparing sustainability among countries. However, as the result of various statistical evaluations and extensive economic theory research the debate of what comprises the best evaluation of sustainability we can make a conclusion that the compromise could be found between 3 general elements: consumption growth (especially when talking about consumption of social services provided by government is exchange for taxes) should not be smaller than technological growth (because in this case current generation gives up their welfare for the benefit of growth of future generation); if the surplus of both is relatively equal – the balance can be considered

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fair; the third component is savings – savings surplus is equally important for current and future generations (it serves as a security tool) and must be evaluated in the context of balance between welfare and technological surplus.

Sustainability is the ability of a system to function under circumstances close to equilibrium, even in conditions of constant outside and internal disturbing influences. Growth sustainability is a concept that goes ahead of time, as technological progress and investments in future generation together with necessary investments towards current generation and essential savings safety net are the components of predictable development of any country.

Latest research and publications analysis. Theory of sustainable growth has been discussed for a long time, for example, by H. Hotelling (1931), J.R. Hicks (1946), R. Solow (1974), J. Hartwick (1977), T. Page (1977), D. Collard, D. Pearce et al. (1988), C. Conroy, M. Litvinoff et al. (1988), D. Pearce, M. Redclift et al. (1988), R. Turner et al. (1988), M. Marien (1989), L. Hilbrath (1990), R. Barro and X. Sala-I-Martin (1995), F. Harrison and G. Titova (1997), M. Carr (1998), D. Pearce and E. Barbier (2000), T.V. Terentieva and M.A. Bobureva (2011).

L. Brown (1981) most explicitly and fully presented the key approaches for the concept of sustainable growth in his book "Building a Sustainable Society".

Unresolved issues. Though we highly evaluate the findings of scientists and economists and their practical and theoretical contributions, it is important to point out that neither Hotelling's model, nor literature on optimal models for growth give explicit answers to the question how to evaluate the level of sustainable growth of a country. Thus, the goal posed by this research is timely and necessary to be achieved.

The research objective. The goal of this research is to evaluate the growth sustainability of China, Japan, Republic of Korea, and Taiwan from 2000 to 2010.

Methods. This research focuses on the assessment (and further comparison) of growth sustainability for China, Japan, South Korea and Taiwan based on time series data for the years between 2000 and 2010 measured through the introduced inequation:

$$\Delta T - \Delta P \le \Delta S, \quad (1)$$

where ΔT is the technological surplus; ΔP is the population surplus and public expenditures dynamics; ΔS is the savings surplus.

ΔT for every country is calculated basing on the yearly data for: a) volume of high-tech export; b) labor productivity; c) R&D spending, d) license royalties.

ΔP for every country is calculated basing on the yearly data for: a) education expenditures; b) governmental social security expenditures; c) governmental expenditures on retirement; d) healthcare expenditures; e) population between 15 and 64 years old.

ΔS for every country is calculated basing on the yearly data for: a) gross domestic income; b) quasi money; c) cash holdings.

Dynamics of time series data represents the growth rates (as opposed to calculated absolute growth). Since the growth rate for every variable is calculated based on the difference between "current" and "previous" year, the presented in the paper statistics starts from the year 2001, however it is important to keep in mind that the 2001 rate is a dynamics that covers the year 2000 as well.

At a later phase, we calculated the statistical medians of ΔT, ΔP and ΔS. At a final stage, inequation (1) is analyzed for every year assessing growth sustainability of a given country.

Key research findings. We collected broad range of necessary time series data, explained explicitly in Methods, and calculated the growth rates dynamics for every variable of the inequation's elements. We then calculated medians of the inequation's elements and present the final results below. In order to be able to better depict the situation for every country we present the results graphically as well.

Table 1. **China, 2000–2010. Calculation of inequation elements on time series data, sustainability testing** $\Delta T - \Delta P \leq \Delta S$

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
ΔT	1,218	1,343	1,291	1,208	1,205	1,022	1,179	1,006	1,060	1,132
ΔP	1,123	1,131	1,114	1,130	1,089	1,173	1,205	1,189	1,009	1,032
ΔS	1,150	1,165	1,184	1,111	0,536	1,209	2,455	0,547	2,644	1,128
$\Delta T - \Delta P$	0,095	0,213	0,177	0,079	0,116	-0,151	-0,026	-0,183	0,051	0,100
Conclusion	Sustainable Growth									

Source: The World Bank (2000–2010); Encyclopedia of the Nations (2000–2010); Index Mundi (2000–2010); Ministry of Education of the People's Republic of China (2000–2010); The Central People's Government of the People's Republic of China (2014); Nation Master (2000–2010); National Bureau of Statistics of the People's Republic of China (2000–2010); OECD (2000–2010).

Thus, the first decade of new millennium in China contributed to sustainable growth as its technological surplus minus population surplus with public expenditures dynamics was lower than savings surplus. Statistics was relatively stable, with few important deviations: from 2006 to 2008 population surplus and public expenditures dynamics was higher than technological surplus; savings surplus had been fluctuating considerably, showing some instability in China's development between 2000 and 2010.

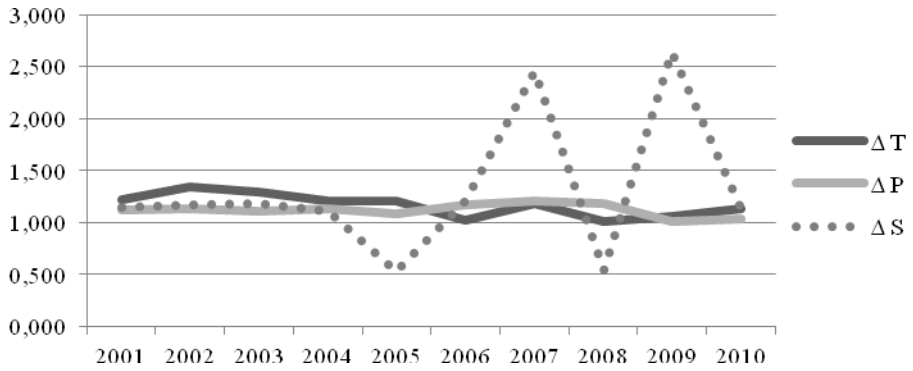

Figure 1. **China, 2000–2010. Sustainability elements** ΔT, ΔP, ΔS, *compiled by the authors*

All the 3 elements of inequation had been about the same level (Figure 1). However, capital surplus went through sharp growth and drops. Sharp fluctuations of savings started in 2005 and continued till the end of the analyzed period. Such fluc-

tuations depict instability of China's ability to sustain savings growth at a desirable level. Up until 2005 technological surplus was the fastest growing variable. Starting in 2005 population surplus and public expenditures dynamics overgrew technological surplus.

Calculations in Table 2 show that Japan as well passed the sustainability test for the given period. Up to 2007 technological surplus was higher than population surplus with public expenditures dynamics. Technological surplus started to go down in 2004 and reached the minimum in 2009. Opposite to China, Japan has shown relative stability in savings, which after having its lowest in 2005 started to pick up after, however there were no serious fluctuations. Figure 2 clearly shows that all the elements of the inequation had been relatively on the same level, indicating sustainability. In 2010 all 3 elements grew as compared to 2001.

Table 2. **Japan, 2000–2010. Calculation of inequation elements on time series data, sustainability testing** $\Delta T - \Delta P \leq \Delta S$

	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010
ΔT	0,918	0,988	1,112	1,110	1,034	1,034	1,019	1,026	0,912	1,010
ΔP	0,916	0,971	1,073	1,067	0,938	0,960	1,049	1,089	1,009	1,037
ΔS	0,838	0,926	0,933	1,017	0,996	0,987	0,999	1,019	1,013	1,046
$\Delta T - \Delta P$	0,002	0,018	0,039	0,043	0,096	0,074	-0,030	-0,063	-0,097	-0,028
Conclusion	Sustainable Growth									

Source: The World Bank (2000–2010); Index Mundi (2000–2010); Nation Master (2000–2010); Encyclopedia of the Nations (2000–2010); OECD (2000–2010).

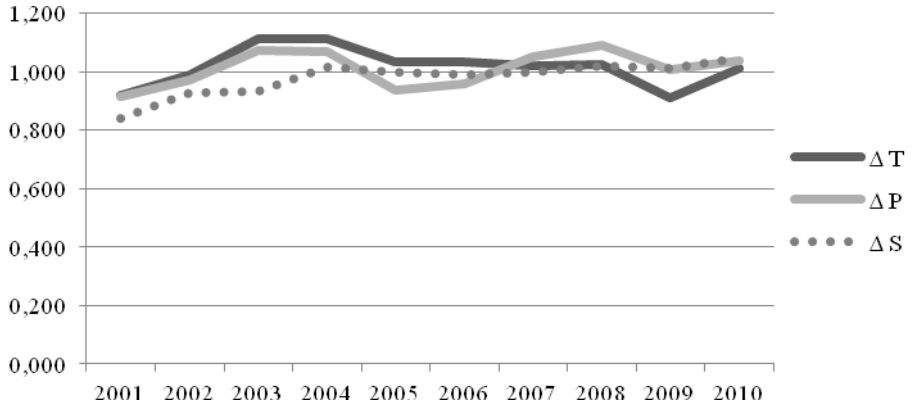

Figure 2. **Japan, 2000–2010. Sustainability elements** ΔT, ΔP, ΔS, *compiled by the authors*

Republic of Korea passed the sustainability test for the given time frame. Technological surplus went hand in hand with population surplus and public expenditures dynamics for the most part of the decade, however from mid 2004 up to mid 2006 population surplus and public expenditures dynamics were greater, since 2008 till the mid of 2010 was lower than technological surplus, and started picking up again after mid 2010. As seen in Table 3 savings surplus has been greater than the difference between ΔT and ΔP, and it had been stable, without fluctuations. As far as the dynamics concerns, Korean savings surplus showed the least growth out of 4 countries, in

fact, it showed a drop in a growth rate in 2010 as compared to 2001. Technological surplus and population surplus with public expenditures dynamics grew during the decade.

Table 3. **Republic of Korea, 2000–2010. Calculation of inequation elements on time series data, sustainability testing** $\Delta T - \Delta P \leq \Delta S$

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
ΔT	0,925	1,076	1,154	1,200	1,095	1,094	1,130	1,001	1,019	1,141
ΔP	0,964	1,107	1,158	1,143	1,170	1,124	1,105	0,968	0,921	1,224
ΔS	1,087	1,081	1,044	1,038	1,046	1,058	1,039	1,075	1,058	1,084
$\Delta T - \Delta P$	-0,039	-0,031	-0,005	0,057	-0,075	-0,030	0,025	0,033	0,097	-0,083
Conclusion	Sustainable Growth									

Source: The World Bank (2000–2010); OECD (2000–2010); Encyclopedia of the Nations (2000–2010); Nation Master (2000–2010).

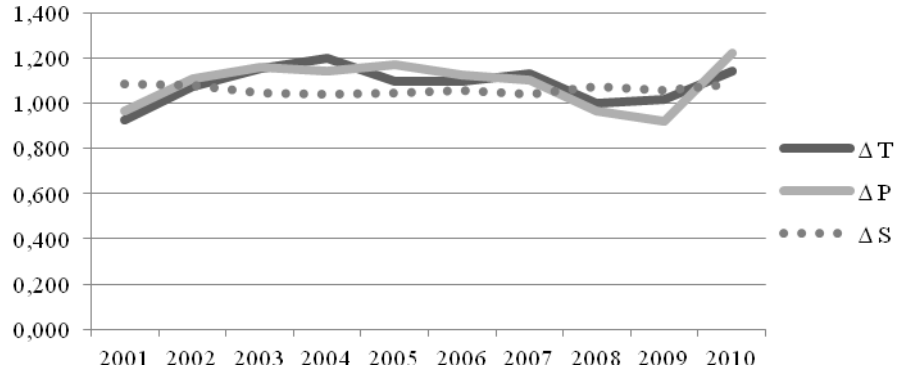

Figure 3. **Republic of Korea, 2000–2010. Sustainability elements** ΔT, ΔP, ΔS, *compiled by the authors*

Table 4. **Taiwan, 2000–2010. Calculation of inequation elements on time series data, sustainability testing** $\Delta T - \Delta P \leq \Delta S$

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
ΔT	1,084	1,228	1,095	1,137	1,083	1,119	1,091	1,073	0,996	1,158
ΔP	0,814	0,951	1,020	1,012	1,033	1,016	1,002	1,013	1,035	1,023
ΔS	1,010	1,011	0,655	1,622	1,055	1,057	1,024	1,064	0,972	1,011
$\Delta T - \Delta P$	0,270	0,277	0,075	0,125	0,050	0,103	0,088	0,060	-0,039	0,135
Conclusion	Sustainable Growth									

Source: Council for Economic Planning and Development (2011); Index Mundi (2000–2010); StatInfo: International Economic Statistics (2000–2010); Encyclopedia of the Nations (2000–2010); Nation Master (2000–2010); OECD (2000–2010); The World Bank (2000–2010).

Taiwan passed the sustainability test, and like China showed serious fluctuations in savings surplus. As shown in Figure 4 savings surplus hits its lowest level in 2003, rapidly striking to its highest level in 2004, after that it came back to the level it started the decade. In the end, savings surplus did not change in 2010 as compared to 2001. On the other hand, population surplus and public expenditures dynamics had been constantly lower than technological surplus up to mid 2008, there was a small period in 2009 when technological surplus was higher, however it ended soon. Such

interesting dynamics shows that though Taiwan manages to save over difference between investing in human capital and resulted from it technological progress, its investment in what maintains human welfare had been considerably lower than the investment in technological development.

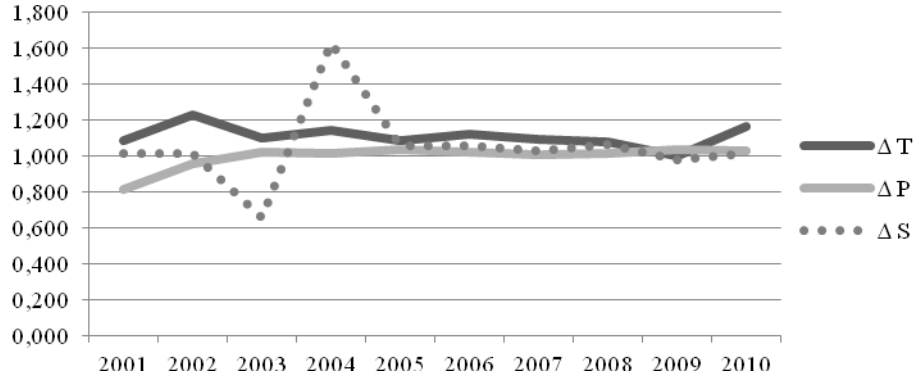

Figure 4. **Taiwan, 2000–2010. Sustainability elements** ΔT, ΔP, ΔS, *compiled by the authors*

Discussion. We depicted the results graphically in order to analyze visually the results of the sustainability testing. In addition, we compared all the elements of the inequation among countries.

Figure 5 depicts the difference between two sides of inequation (savings surplus on one side and technological surplus minus population surplus with population expenditures dynamics), which shows growth sustainability for the given countries. The largest and the most stable difference between two sides exists for Korea, meaning that the country managed to preserve its sustainable growth through correct balance between investment in technological development, current human welfare, and gain adequate to the expenditures savings surplus, projecting stable potential growth and safety net for future generation.

Though Korea's situation is not perfect because it did show certain fluctuations in both technological surplus and population expenditures dynamics. China, Taiwan, and Japan had smaller difference, however Japan showed most improvement. China and Taiwan had the worst fluctuations, meaning that future generations in those countries will face most difficulties in balancing growth and social welfare. China and Taiwan did pass the sustainability test (as well as Japan), but they are still not quite stable.

Figure 6 depicts the comparison of all the 3 elements of the inequation that allows us comparing countries more closely in addition to comparison of their growth sustainability. All 4 countries showed considerable fluctuations in population expenditures dynamics. From this perspective, Taiwan showed the most stability: the number grew from the lowest point of all 4 countries after 2003 and remained stable up to 2010.

Though having the biggest imbalance in the difference of surplus between technological progress and social expenditures dynamics, Republic of Korea showed the best result considering the financial crisis in 2008, the number picked up in 2003 and

remained stable for several year until the world financial crisis that ragged the number low very fast, however it is important to notice that Korea managed to bring the surplus back and as of 2010 it showed the best result in both: change in surplus in 2010 as compared to 2001 and the highest surplus in 2010.

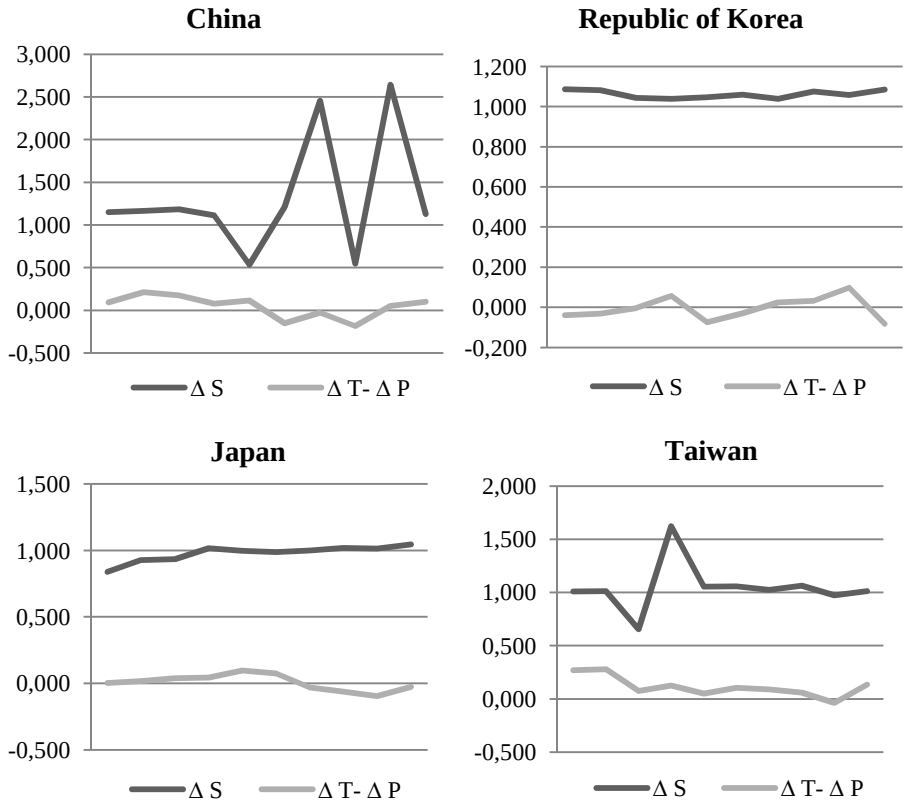

Figure 5. **Sustainability testing $\Delta T - \Delta P \leq \Delta S$ presentation for China, Japan, Korea and Taiwan, 2001–2010,** *compiled by the authors*

Though Japan managed to grow the surplus in social expenditures dynamics, its fluctuations were considerable.

China showed the worst result, from relatively stable surplus for several years, it started to fluctuate considerably, and in 2010 fell below the original 2001 number.

All 4 countries showed considerable fluctuations in technological surplus, meaning that investments in progress of different economic sectors are not sustainable in its strategic application. China had lowered its technological surplus considerably in 2010 as compared to 2001. Taiwan ended up relatively on the same level in 2010 as compared to 2001. Japan has grown technological surplus, though not significantly. Republic of Korea had the best result: though with large fluctuations, it grew it surplus largely.

As far as savings surplus, Taiwan and China showed large fluctuations, China in a large degree. Japan and Korea both were relatively stable. All 4 countries did not show big improvements in growing the savings surplus.

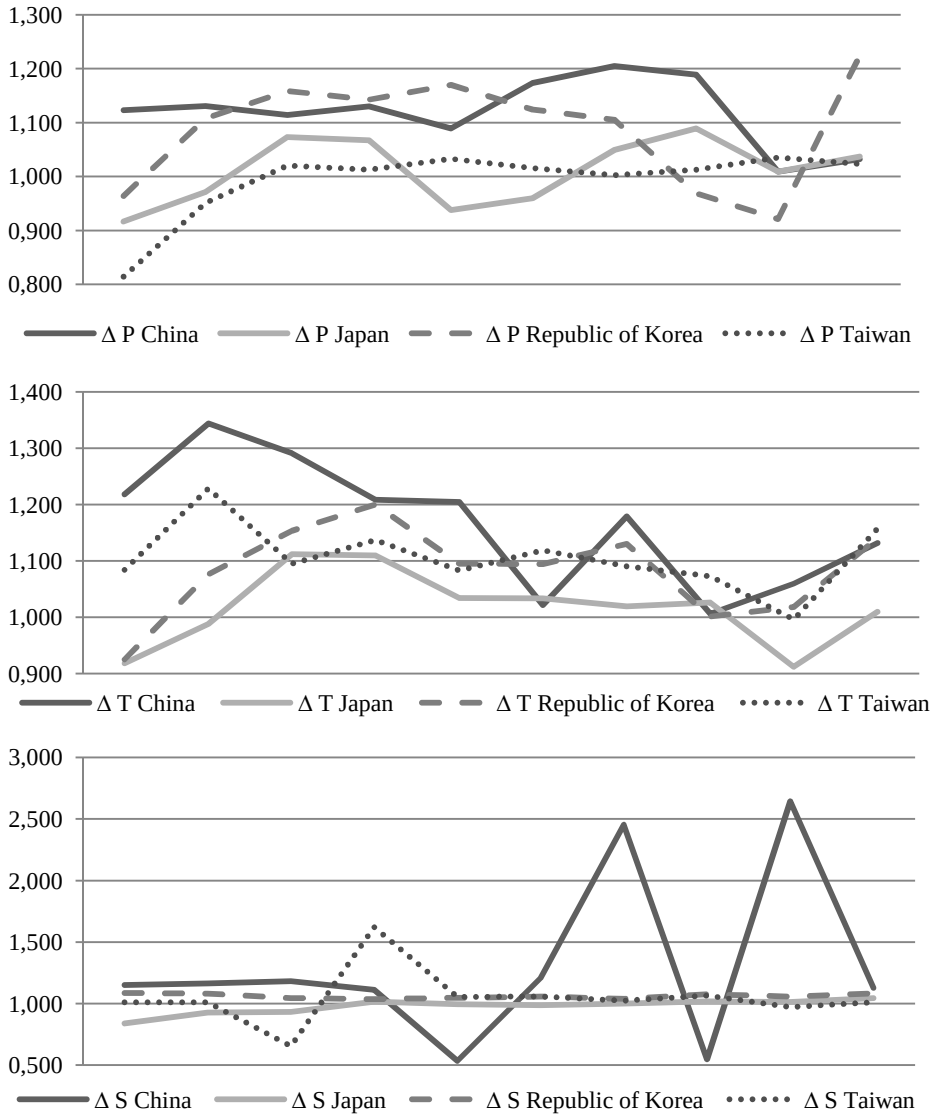

Figure 6. **Comparison of elements in the sustainability inequation,** *compiled by the authors*

Conclusions. All the researched countries – China, Japan, Republic of Korea, and Taiwan, in the first decade of the second millennium (between 2000 and 2010) had demonstrated sustainable growth. It is also important to point out that despite economic growth the given countries experienced fluctuations and were characterized by considerable differentiations in sustainability, growth balance and social welfare. Fair distribution of resources between welfare of the current generation and investments in growth for the sake of future generations as a concept had been failing to sustain. Testing the growth sustainability with $\Delta T - \Delta P \leq \Delta S$ inequation showed

that all 4 countries did maintain relative balance between technological progress surplus and population surplus with public expenditures dynamics, but only Korea and Japan managed to maintain considerable and stable savings surplus. Taiwan, and most importantly China had showed large fluctuations that allow drawing a conclusion that growth sustainability of these countries is very vulnerable. When looking closer at separate elements of the left side of the inequation, all 4 countries showed very considerable fluctuations and though superficial balance between welfare of current generation and investments in future generations was managed, the real stability was not yet achieved.

The level of growth sustainability of the given countries had been substantially changing through the period. China saw the minimal stability and most intense fluctuations out of the countries which might have led to misbalanced economy and more of economic and social problems. It is also important to notice that Taiwan managed to stabilize even despite of the world financial crisis, however, the imbalance between the current welfare and investment in technological progress was too sharp, which theoretically is good for economic growth, but practically it discourages the population in relation to weak welfare, which in its turn discourages production. Japan and Korea did show the best result, as it is expected given the history of their national economies. These countries also managed to maintain the best balance between welfare and technological progress; also they did maintain the best savings surplus.

Overall, we can see that though some countries develop faster and achieve more stability, the concept of balanced sustainable growth is not explored enough on a governmental scale; the complex systems of national economies are managed from the perspectives of immediate necessities and short-term strategies.

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