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# Productivity Convergence of High-Tech Automotive Industry in Asian

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## ABSTRACT

This study is attempting to study the convergence of high-technology productivity of the automotive industry in Asia. This study uses time series data collected from 10 Asian countries from 2002-2016. In addition, this study was tested using the panel method proposed by Phillips and Sul (2007a), to identify whether the convergence of automotive technology high-tech productivity convergence or divergence. The results for full panel convergence in this study show divergence. However, in this study there were three convergence clubs found. The first clubs are Japan, South Korea and Thailand, the second club is Indonesia and Iran while the third club is Malaysia, Vietnam and the Philippines. This study suggests that governments need to play an important role to implement good policies to attract more Asian countries to work with each other. This study can be summarized that economies in Asian countries experience different levels of development and the shift in economic behaviour is very different among Asian countries.

Keywords: Convergence, Divergence, Asian, Automotive industry



## INTRODUCTION

High-tech can be defined as a high-technology industry where a group of companies involved in high-technology products in terms of research, development, production and technical services. Most technology products of a country must be included in high-tech processing (Ding, 2016). High-tech can characterize by knowledge of e-intensity and technology-intensity which represent the comprehensive strength and the overall competitiveness of a region or country. Moreover, in the economic perspective which to use or develop advanced technologies known to the public is potentially leading to higher investment and resulting for future growth of a country. The productivity convergence in high-tech automotive industry is depending on the request from the customer. Therefore, future innovation will focus on technology trends to the customers. Automobile manufacturers will look in terms of technology trends such as electrification, autonomous driving, diverse mobility, and connectivity.

According to Ding (2016) the most important of the high-tech industry in Asian is in the development of the high-tech industry that has growth of national economics and the sector has become an area of focus for many countries as it adds significant value to their economic. Where since the year 1980s, the diffusion of the technology brought on by globalization, so the high-tech industry has become an important area international economic competition in the world (Liu & Tsai, 2007). The importance of high-technology industries, especially automotive that enables a country to be more developed on the value chain. This enables the spread of advanced technology in the industry and moves towards acquiring more technology-based firms than those employing the workforce. This will increase the reputation of the market and the firm's performance will become more efficient and increase the country's revenue. Furthermore, this will make a country specialize in high-tech automotive and increases the growth domestic product (GDP). Developing countries have problems with the productivity convergence of high-tech where the failure new technology to boost productivity that knows as Solow Paradox. It is that technological advances increase productivity only after a long lag and this might lead to fear of the job-destroying effect. According to Bai and Ng (2004) a test that distinguishes between non-stations, which is not convergence, which is derived from one or the same source or variable. For the whole economy, the overall indication of convergence cannot be traced back to both factors indicating that not only the country's specific arguments need to be considered. On the other hand, developments or technology stocks that are often experienced have led to more differences across the Europe region and overall economic perspective are ensured when looking at the major sectors of the Europe region. The problem is Japan use many more industrial automotive than in emerging countries, though China is beginning to invest heavily in automotive as its labour costs rises. So, often branded as

the lump of labour fallacy, where belief that there is only so much work to go around so if the machines do more of it and less is left for another. This is fallacious because as technology displaces workers from an occupation, it enriches other who spend their gains on good and services that create new employment for the worker whose job have been automatic away with machines. On the other hand, high-tech is often viewed as high risk, but offering the opportunity for high profit to countries. So, if the countries have low technology can give impact to the productivity. Hence, Japan has made substantial contributions to various fields such as electronics, machinery, earthquake engineering, automotive, optical, industrial robotics, metal and semiconductors. Furthermore, this study is intended to find the key competence factors that can contribute to the high-tech productivity convergence in the automotive industry in Asia. Besides that, it is also important to find out the affect productivity convergence of high-tech in Asian as objective of this study.

Convergence Theory

According to Crossman (2017), convergence theory is a theory that assumes that countries are in the early stages of industrialization and resemble other industrialized nations. Money from other countries can be poured out for developing countries and can take advantage of these opportunities. These countries will become more vulnerable to the international market. Not only that, convergence in the economy or better known as the catch-up effect has hypothesized that the poor country has per capita economic income will be more likely to grow at a faster pace than the rich country. This is because, the decline in returns, especially capital that is not comparable to the capital-rich nation. Therefore, poor or developing countries can follow the methods of production, technology and institutions of developed countries. In addition, convergence theory is an economic theory that assumes that the concept of development takes place is a good thing universally and determined by economic growth. This will be able to unify the developing countries with advanced countries. This is because, the economies of developing countries are increasingly expanding from most developed industrial countries. That is, all nations must unite to achieve the same level. Furthermore, divergence is different from convergence because divergence happens when two points are not united to one another. Divergence in the economy occurs when capital invested in poor countries and the international market does not know or do not know that there are investment opportunities in the country then catch-ups will not happen. This will be the economic divergence. The unstable countries will be more likely to divergence because there are social and political factors such as lack of job opportunities or infrastructure.

## MATERIALS & METHODS

Data Description

This study is about productivity convergence of high-tech automotive industry in Asian which selected several countries as a study case such as Japan, China, South Korea, India, Thailand, Indonesia, Iran, Malaysia, Vietnam, and Philippines. In this study, the ranking of countries will be determined based on higher of productivity convergence of high-tech. The variable is total of productivity after total of production (TOP) divided by wage or salaries (WG). All the data used for this empirical analysis study obtained from the OICA production statistics and World Bank Data. In this study, all the data used are annual data, from the year 2002 to 2016.

The Non-linear Factor Model

This study applies a nonlinear time varying factor model from Phillips and Sul (2007a), this has some advantages to studying the shifting of high-tech automotive industry in Asia. This is because, it includes simple linear regression and single-sided regression coefficient tests with standard normal critical values. This method is useful for observing and measuring the transition to long-term growth paths and individual transitions over time, over the common trend, representation or aggregate variables. Therefore, to investigate the convergence of high-technology in the automotive industry in the Asian it is necessary to use the appliances applied by Phillips and Sul (2007a). Panel data are usually decomposed by:

$$X_{it} = g_{it} + a_{it} \quad (1)$$

In equation (1) $x_{it}$ is a panel log income per capita for nation i, (i = 1,…,N) and at time t = 1,…,N. It is common to decompose $x_{it}$ into two components as systematic, git and transitory, $a_{it}$. At the point, we do not assume any parametric assumptions of $g_{it}$ and $a_{it}$, it is because the framework may include linear, nonlinear, stationary and non-stationary processes. In equation (1) may contain both common and idiosyncratic components in $g_{it}$ and $a_{it}$.

$$X_{it} = \left(\frac{g_{it} + a_{it}}{\mu_{it}}\right) \mu_t = \delta_{it}\ \mu_t \ \ for\ all\ country, i\ and\ time, t \tag{2}$$

Using equation (2), the common and idiosyncratic factors in the panel can be separated by Phillips and Sul (2007a) through factoring the common stochastic trend component. Equation (2) state that $x_{it}$ is decomposed into two components: common $\mu_{it}$ and idiosyncratic $\delta_{it}$. The component $\delta_{it}$ it is a measure of distance between $x_{it}$ the common component, $\mu_{it}$ . This is absorbing the error term and the unit specific component and hence serves as the idiosyncratic component which is changing over time. The common trend component in the panel denoted by $\mu_{it}$ , is assumed to have some deterministic or stochastic trend attitude that influences the transitory component $a_{it}$ as $t \to \infty$. In order to specify the null hypothesis of convergence, the non-stationary transitional nature of factor loading is proposed in semi parametric form, so that each coefficient converges to some unit specific constant:

$$\delta_{it} = \delta_i + \left(\frac{\sigma_i + \xi_{it}}{L\,(t)t^{\alpha}}\right) \tag{3}$$

Where it $\delta_{it}$ is fixed, it $\xi_{it}$ is iid (0,1) across i, I $\sigma_i$ are idiosyncratic scale parameters, slowly varying function is represented by L(t) and L(t)=log t so that $L(t) \to \infty$ as $t \to \infty$ . The rates at which the cross-sectional variation decaying to 0 is denoted the parameter α. The formulation above ensures that $\xi_{it}$ it converges to $\xi$ for all $\alpha \geq 0$.

The Transition Path

Estimation of the time varying factor loading $\delta_{it}$ it is a central issue of the approach proposed by Phillips and Sul (2007a), since the estimates deliver information about transition behaviour of panel units. So, by applying its corresponding form, a smooth and effective method to obtain fact about the $\delta$ it is as regard:

$$h_{it} = \frac{x_{it}}{\frac{1}{N}\sum_{i=1}^{N} x_{it}} = \frac{\delta_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}} \tag{4}$$

In equation (4), measure the loading coefficient $\delta_{it}$ it in relation to the panel average. For economy i, alike to $\delta_{it}$, $h_{it}$ is still traces out a transition path through present produces one is in association to panel average. Over time, the variable $h_{it}$, trace out an individual trajectory for each i relative to the average that why it is called as transition path. Together, from the common steady state growth path $\mu_t$ of the country i's relevant deviation is as well measure by $h_{it}$. Thus, any divergences from $\mu_t$ are reflected from the transition path $h_{it}$. By the forming, the average of cross-section of the corresponding path of transition of i equal unity. Addition, the relative transition path hit converges to unity and the cross-sectional variation (Ht) of the relative transition path converges zeroes, if the panel units converge and all the factor loading $\delta_{it}$ it approximates to fixed $\delta$, which is as follows:

$$H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{it} - 1)^2 \to 0, t \to \infty \tag{5}$$

These properties are used in testing the convergence null hypothesis. Therefore, the null hypothesis can be determined by $H_0 : \delta_i = \delta$ and $\alpha \geq 0$ for all i, and the alternative hypothesis is $H_0 : \delta_i \neq \delta$ for some i, or $a < 0$. so, in some countries the alternative hypothesis does not show convergence, but in the null hypothesis can indicate convergence for all countries. To analyze convergence concepts, can indicate that the app follows the long-term behaviour in macroeconomic data. Thus, it is usually desirable to eliminate business cycle factor using smoothing technique to obtain hit from $X_{it}$. So, according by extending (4) to Incorporated a business cycle effect $k_{it}$, it can be written as:

$$X_{it} = \delta_{it}\,\mu_{it} + k_{it} \tag{6}$$

Due to the adaptability and the points that Hodrick and Prescott (1997) smoothing filter quest simply the addition of smoothing series and bot looking for preceding particularization of the characteristics of the common trend $\mu_t$ in $X_{it}$ in this analysis that Hodrick and Prescott (1997) smoothing filter is adopted. That having the computed the HP estimate:

$$\hat{X}_{it} = \hat{\delta}_{it}\,\hat{\mu}_{it} \tag{7}$$

Extending the above, the cross-sectional averages in (4) lead to the estimated transition path computed as:

$$\hat{h}_{it} = \frac{\hat{X}_{it}}{\frac{1}{N}\sum_{i=1}^{N}\hat{N}it} \quad (8)$$

Where $\hat{X}_{it}$ are the filtered income per capita series. Within the expectation, in samples, the panel average $N^{-1}\sum_{i=1}^{N}X_{it}$ is positive also asymptotically that is performed for many related economic time series for instance, price, gross domestic product or other aggregates.

The Log t Test Regression

Base on the time varying the factor in the equation (2) and depending on the log t convergence test that is depending on a simplistic time series regression of Phillips and Sul (2007a) proposed a unique convergence test and clustering algorithm, which involves a one-sided t-test. The test is known as t-test as the t-statistic refers to the coefficient of log t regression in the equation. After estimating the transition path, the variance ratio of cross section $H_1/H_i$ is to be computed by acknowledging $X_t$ as:

$$H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{i1} - 1)^2 \quad (9)$$

The transition distance of Ht has a limiting form as shown below:

$$H_t \sim \frac{A}{L(t)^2\, t^{2a}}, t \to \infty \quad (10)$$

Where A is a positive constant, L(t)=log (t+1) is a slowly varying function and the speed of convergence is α. Usually, after removing a fraction (r) of the sample, in equation (11) is tested. In addition, it is suggested that some point i, become (rT) where (rT) represents the integer art of (rT) and r=0.3. For examining the convergence null hypothesis discussed above, the log t test is carried out as regards by:

$$\log H_1/H_i - 2\log L(t) = \hat{c} + \hat{b}\log t + \hat{\mu}_t \quad t = (rT),\ldots..T \quad (11)$$

Where $H_t$ is the cross-sectional variation $H_1/H_i$ is the ratio of the cross-sectional variation at the beginning of the sample, H1 (i.e Ht at t = 1) over the respective variation for every point in time t, that is Ht (t,…,T). The ratio $H_1/H_i$ measures the distances of the panel from the common limit. At the same time, L(t) = log (t) and r > 0. Thus, the regression presented in equation (6) is known as log t regression due to the log t regressor. The value of $\hat{b}$ is higher or greater, as the rate of convergence is faster. It can be a conditional build up as it tests whether heterogeneous varied idiosyncratic components converge along with the continuous time after controlling growth components within the country. By applying the transitional t-statistic, if $t_b$ < - 1.65 (5% significance level), we reject the H 0 of convergence. It can be concluded panel convergence when the statistics, $t_b$ recommends that $\hat{b}$ is else positive otherwise equal to 0. To reject convergence as a whole, the test procedures applied to subgroups are in accordance with clustering mechanism testing procedures in Phillips and Sul (2007b). On the other hand, we reject H 0 convergence, when the statistics, $t_b$ recommends that $\hat{b}$ negative and significant.

## RESULTS AND DISCUSSION

Full Panel Convergence

The productivity convergence of high-tech automotive in Asian countries was analyzed using full panel convergence. The rank of the countries needed to be rank based on higher value and followed by others. Then, by using log t-test, the productivity level was determined by full panel convergence. Finally, this result can be determined either productivity convergence or divergence as shown in Table 1.

**Table 1:** Full Panel Convergence (Productivity Convergence).

| Club | Country | T-Statistic | Remarks |
|---|---|---|---|
| Full Sample | Selected Asian Country | -12.64849** | Divergence |

Notes: Asterisk (**) denoted statistically significance at the 5% level. The 5% critical value is -1.65.

The t-statistics of -12.64849 indicating the rejection of the null hypothesis of convergence at the 5% significance level or t-statistic less than -1.65. This is because if the result is more than -1.65 ($t_b$ > -1.65) that means the result are converging but, if the result is less than -1.65 (tb < -1.65) so, that means the result are diverging. Hence, the null hypothesis of full panel convergence is rejected for the period specified from 2002-2016 when the data cropping takes place focusing on the final part of the sample data. This is because, in Phillips and Sul (2007a, 2007b, 2007c) theory, it is believed that the regression empirical log is based on the current data where the first r% or 0.3 data is released prior to analysis. For selected Asian countries, the period is from 2007 to 2016, to reject the null hypothesis for absolute convergence. This is because it can show the difference between a group of developed countries and less developed countries in high-tech automotive industry. Furthermore, these methods are based on factors that vary over time and data do not need to carry out stationary data to meet the problem of sample data stations. This indicates that the entire selected Asian country is heterogeneous in terms of productivity convergence. However, this does not mean that there is no convergence in Asian subgroups that carry further analysis for the period of data that has been cut or ignored 0.3 from the initial data. In the theory of Phillips and Sul (2007c) cointegration and convergence is very relevant, but both have different characteristics and the cointegration test does not work as a test to test the next convergence. Not only that, they also believe that there are many possibilities if full panel convergence is removed. Therefore, the Philips and Sul method are highly adaptable for use in the next part.

Cross Sectional Variation

The transition path productivity convergence in Asian from 2007 to 2016 was illustrated in Figure 1. This is due to avoid the initial impact of the beginning of the base year, the first 5 years of yearly observation out of 5 are discarded and only 10 filtered of observation is being used in this analysis. This is because refer to the r= 0.3.

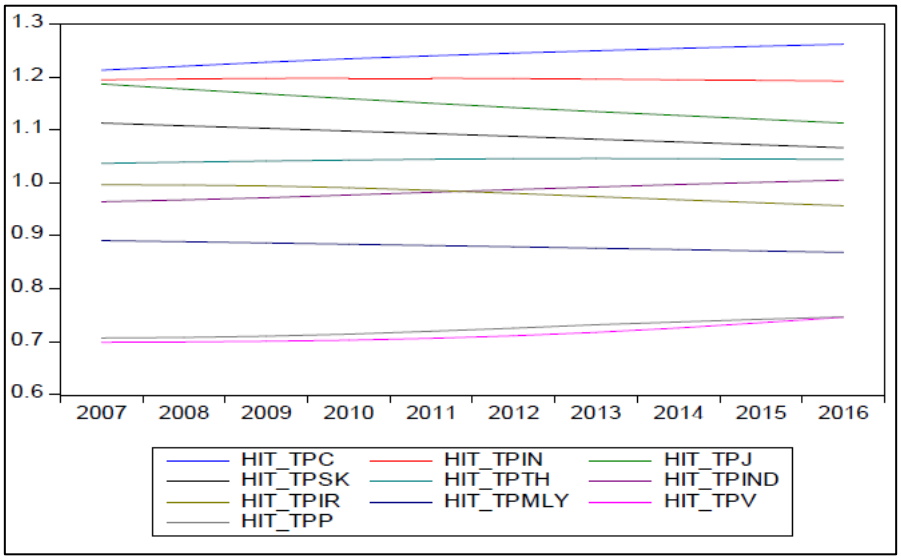


**Figure 1:** Transition Path for Productivity Convergence in Asian.

The behaviour of convergence productivity is closely related to the panel. The path of transition hit, occupies a growth path for each country and is related to the average sample and can show convergence productivity in the automotive industry that exceeds average cross-section or otherwise. Furthermore, the relevant transition path leads to unity for all countries by assuming convergence across the country panel. In addition, the slope of each curve is represented by the convergence productivity growth rate for the relevant country along with the average cross section. Through Figure 1 shows, a whole panel of different convergence, so it can be inclined to unity the transition path. In Figure 1 shows that there are several countries, crossing or equilibrium points. For example, the country of Indonesia (HIT_TPIND) and Iran (HIT_TPIR) and Vietnam (HIT_TPV) and Philippine (HIT_TPP). These four countries show clearly that have convergence between them. Not only that, looking at the final year in

this data shows that Vietnam can catch up the Philippine country in the coming year as this figure of productivity for Vietnam is increasing with each year. Furthermore, China (HIT_TPC) total productivity is the first ranking in this group. This is because it has the highest total productivity among other countries. In the diagram shows that China is constantly increasing with each year. Not only that, the China country freely moves in the transition path and does not achieve equilibrium with other countries. This shows that a China country is likely to achieve divergence where rejecting the null hypothesis in convergence. While, based on this figure that show Malaysia (HIT_TPMLY) from the beginning around the year 2007 had shown transition parameter highest but slowly goes down in along the period and show the transition parameter is lowest. This show that Malaysia country have achieve convergence in this analysis.

From Table 2, China is the first rank and the base country for this analysis. The second country will be added to run log t regression. Next, computed the t-statistic until the value of the t-statistic is less or more than -1.65. So, continuing this method by adding India to China and get the t-statistic is -24.7503. This result is -24.7503 is less than -1.65 so other country is stop added. Next, India was taken by to be a base country and Japan is added to India while the t-statistic is -8.240443. Because of the value is less than -1.75 so stop added. Japan was taken as a base country and South Korea is added to Japan and the t-statistic is 0.336316. The result is more than -1.65 continuing to add. Then, added Thailand to Japan and South Korea with the t-statistic is 6.337347 is continues added. Indonesia added to Japan, South Korea, and Thailand. The t-statistic is 4.167087 stops added. This is because the value is lower than value 6.337347. There are two rules in club convergence that is less or more than -1.65 and compare with the previous value. If the present value is lower than the previous value, then it stops adding a new country. Indonesia was taken as a base country and Iran added to Indonesia. The t-statistic is -0.746012 continues added. Malaysia added to Indonesia and Iran. The t-statistic is -38.74240 stop added. Malaysia was taken by to be a base-country and Vietnam added to Malaysia. The t-statistic is 0.250618 continues added. Philippines added to Malaysia and Vietnam. The t-statistic is 0.450611 and this result is more than -1.65. The convergence exists in most Asian countries which are the club 1 includes Japan, South Korea, Thailand, club 2 consists of Indonesia and Iran and the club 3 involves of Malaysia, Vietnam and Philippine. For club 1, Japan will be a heading for South Korea and Thailand. While club 2, Indonesia will be a heading for Iran and club 3, Malaysia will be a heading for Vietnam and Philippine. The formation of this clubs has reached the objective of this study where there is clubs' convergence in high-tech automotive industry in Asia. This is determined by comparing the t-statistics given in the critical value results. So, to know whether the subgroup is converging is through a t-statistic value greater than the critical value of -1.65. This study shows that the club 1, club 2, and club 3 are converging. If the critical value is less than the critical value of -1.65 then it is considered as divergence. Thus, the country that divergence are China and India.

**Table 2:** Results of Clubs Convergence in Asian.

| Last T Order | Country | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Club | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| **1** | TPC | Base | | | | | | | Divergence |
| 2 | TPIN | -24.75030* | Base | | | | | | Divergence |
| 3 | TPJ | | -8.240443 | Base | | | | 1 | Convergence |
| 4 | TPSK | | | 0.336313 | | | | 1 | Convergence |
| 5 | TPTH | | | 6.337347 | | | | 1 | Convergence |
| 6 | TPIND | | | 4.167087* | Base | | | 2 | Convergence |
| 7 | TPIR | | | | -0.746012 | | | 2 | Convergence |
| 8 | TPMLY | | | | -38.74240* | Base | | 3 | Convergence |
| 9 | TPV | | | | | 0.250618 | | 3 | Convergence |
| 10 | TPP | | | | | 0.450611* | | 3 | Convergence |

Notes: Asterisk (*) denoted statistically significant at 5% level. The 5% critical value is -1.65
Symbols Represent: TPC-China, TPIN-India, TPJ-Japan, TPSK-South Korea, TPTH-Thailand, TPIND-Indonesia, TPIR-Iran, TPMLY-Malaysia, TPV-Vietnam and TPP-Philippine.

## CONCLUSION

Asian has a steady increase in automotive productivity and there is a divergence or no convergence that occurs in the entire panel convergence. However, rich Asian countries have proven to dominate the base group of convergence clubs in high tech automotive driven by automotive wage and production in Asian countries. This study uses Phillips and Sul (2007a) test, to analyze the possibility of convergence attitudes in selected data. Subsequent to the selection of state clusters and to use China (last highest observation) as a benchmark country and can form five different subgroups. In this study it is shown that Malaysia is the lowest convergence in the

group. This is because, there is a shortage of projects in increasing productivity in high tech automotive industries in the country. When lack of improvement in high technology will result in cumulative regional divergence. This is the same as the Krugman (1991) which states that when the lack of improvements in infrastructure will lead to the process of regional deviations. This may indicate that selected Asian countries can catch up with each other.

In conclusion, this study has studied the convergence of productivity of the high-tech automotive industry in Asian countries. Full panel convergence results in this study are diverging but at the convergence club level shows the selected Asian country, there are three clubs that are experiencing convergence and the other two suffer from divergence. In this study have three club convergence, which is club 1 consist of Japan, South Korea and Thailand, club 2 consist to Indonesia and Iran and Club 3 consist of Malaysia, Vietnam and Philippines. Productivity characteristics in the study are to have reasonable wages for employees, having good economic development to increase employee productivity. Secondly, the level of high-tech automotive productivity is to see the skills of workers in the field, productivity development in the country and productivity efficiency in the automotive field.

The automotive industry plays an important role in contributing to improving economic growth. The high-tech automotive industry can benefit the nation by providing high employment opportunities and improving the standard of living, especially for top-class countries like China, Japan and South Korea. Therefore, a divergence state should implement continuous development planning and R&D and innovation. This is because, it can increase exports in the automotive industry and productivity growth of the country. Countries that carry out R&D will continue to gain the edge in improving the high-tech automotive industry. Other than that, Asian countries also need to form regional groups to produce more advanced automotive products. Hence the formation of regional clusters in the high-tech automotive industry will further expand output and be able to accumulate more capital. This group of countries should cooperate with each other in terms of investigation, trade, policy and liberalization. This could create a series of automotive productivity expenditures that can boost economic growth to become more competitive in the international market.

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