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# A STUDY ON THE RELATIONSHIP BETWEEN TAIWAN SEMICONDUCTOR PRODUCTIVITY AND MACROECONOMIC FACTORS

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#### **ABSTRACT**

The use of operating revenue represents a productivity for the supply chain in the semiconductor industry. The semiconductor industry in Taiwan, from the upper, middle and lower the formation of the supply chain between each other, in Taiwan Semiconductor is a very important industry, accounting for Taiwan's GDP about 20 percent. However, Taiwan is an island country, exports are very important for Taiwan's economy, thence the purpose of this study want to explore on the relationship between Taiwan semiconductor productivity and macroeconomic factors. Via Taiwan Economic Journal data, we choose nine variables; operating revenue, North American semiconductor book-to-bill ratio, Export Price Index (EPI), Export order, Rediscount Rate, exchange rate, Taiwan weighed stock index, foreign direct investment, unemployment rate during the first quarter of 2008 to the first quarter of 2015. Augmented Dickey-Fuller test of Level was discovered that some variables have unit root. So that nine variables run co-integration, we found rejecting the null hypothesis, expressed nine variables had a long-term and stable relationship. Further, Granger Causal test obtained that Taiwan weighed stock index vs EPI and Rediscount Rate vs exchange rate both are bidirectional causality. Then, ARDL Model executed a total of 256 combinations, which ARDL (2,2,2,2,2,2,2) was best.

#### **KEYWORDS**

autoregressive distributed lag model, co-integration, granger causal, macroeconomic factor, productivity, semiconductor industry, unit root.

#### INTRODUCTION

ain purpose of this study is to investigate the relationship between Taiwan semiconductor productivity and macroeconomic factors. In line with past literature (Hung and Lu, 2008), net operating revenue was as a production efficiency of output items. Accordingly, we took net operating revenue, which could imply a productivity for the supply chain in the semiconductor industry.

The latest news from the eyeProphet, informs "Taiwan's electronics industry last bunker; Semiconductor crises". That subject mentioned that, electronic products was the major export category, however, the semiconductor was the minor support of electronics. Once, the poor semiconductor exports, the poor performance of the company's revenue. Consequence, investors are reluctant to invest, and Taiwan's stock market will be affected.

Taiwan businessmen Trade's Network Newsletter, section 614 reported that worries reproduction Taiwan's economy must be transformed. Content mentioned that Taiwan is highly open island economy, exports occupy about seventy percent of GDP. In addition, exports and domestic investment and consumption derived accounted for export growth contribution estimated that 60% to 70%. Thus export is the most critical factor in determining the fortunes of the economy.

Businesses are increasingly faced with fierce competition and dramatic changes in today's global markets, forasmuch an elaborative supply chain should be built by selecting appropriate integration software tools that meet business-to-business operational characteristics and link together all partners' ERP systems (Chiu and Shih 2009). On the other hand, Taiwan semiconductor is more by the favor and trust of the international companies to complete the middle and lower reaches of vertical integration and specialization (Lin 2012).

Fang et al. (2014) suggested in order to maintain semiconductor's accounting rate of the world's first, the integrity of the upper, middle and lower stream of IC industry supply chain. Intentionally, we aspire to realize the relationship between Taiwan semiconductor productivity and macroeconomic factors.

#### **REVIEW OF LITERATURE**

On Service Industry Management Review, Fang et al. (2014) Evaluated IC design, IC manufacturing and IC packaging and testing manufacturers of static and dynamic operating performance; understanding of the domestic semiconductor supply chain whichever has the better operating efficiency and productivity, they outcropped IC manufacturing and IC packaging and testing companies are deeply affected by the global recession, and productivity sharply declines. Also, Hsu et al. (2014) estimated the Performance Analysis of Semiconductor Distributors in Taiwan, selecting total assets, employee amount, owners' equity and operating expenses as the input factors, and operating revenue and net profit as the output factor. Thus, we adopt operating revenue to mean a productivity for the supply chain in the semiconductor industry.

Book-to-bill ratio (B/B ratio) for North America-based manufacturers of semiconductor equipment, by HUNG et al. (2013) defined that b / b ratio as the economy is good or bad judgment semiconductor index, greater than 1 indicates manufacturers optimistic about the future of the economy, less than 1 denotes the future of the economy look bad. Further information, Lin and Fan (2014) applied Granger Causality Test to inspect whether the relationship between Leading Indicators (SEMI Book-to-Bill Ratio, Index of Export Orders, Stock Price Index) and Exchange Traded Funds.

Li (2015) illustrated that the real exchange rate expressed in import price index (IPI), the export price index (EPI) and the consumer price index (CPI), maybe productive impact, making the Purchasing power parity (PPP) bias test result. Additionally, Tsay et al. (2004) noted in order to follow the trends in the movement of exports in advance, export orders have long been used as important leading indicators of actual exports by researchers and government officials alike.

Feng et al. (2013) discussed that correlation between rediscount and income interest rates price indexes and exchange rates in Taiwan, the results express that increase of the rediscount rate will cause GDP and prices to be reduced, and cause interest rates and foreign exchange rates to be increased. Likewise, Lin et al. (2014) aimed to survey the Influences for the New Taiwan Dollar Exchange Rate to the International Trade Competitiveness of Taiwan, the empirical results show that the exchange rate movements significantly but negatively impact Taiwan's competitiveness.

Ku et al. (2015) examined that the impact of OFDI on the domestic production, export and investment, the empirical result reveals that OFDI may have a negative effect on domestic export if a firm invested in the low-wage countries, while OFDI may be positively related to domestic export if a firm invested in the developed countries. Similarly, Wu et al. (2014) point out that Impact of Taiwan's Unemployment Rate for International Trade Competitiveness, the empirical results bespeak that the increase in Taiwan's unemployment rate will negatively and significantly affect international trade competitiveness.

Lin and Tu (2009) analysis that The Relationship between Export Orders and Macroeconomic Factors, hitting upon that export price index and Taiwan weighted stock index, Unemployment rate form a continuous positive impact on changes of export order; While, BB ratio, discount rate and exchange rate marked gradual negative track. Within discussions about past literature, we would like to comprehend the relationship between Taiwan semiconductor productivity and macroeconomic factors.

#### RESEARCH METHODOLOGY

#### **DATA SOURCE**

According to Taiwan Economic Journal (TEJ) data, a total of nine variables; operating revenue (unit: NT \$ 10 million), North American semiconductor book-to-bill ratio (B/B ratio), Export Price Index (EPI, unit: USD), Export order (unit: Millions of USD), Rediscount Rate, exchange rate (unit: USD), Taiwan weighed stock index (1966=100), foreign direct investment (unit: Thousands of USD), unemployment rate during the first quarter of 2008 to the first quarter of 2015.

#### METHODOLOGY

We consulted Hill (2009) and utilized Unit Root (Augmented Dickey-Fuller test), Granger Causal. Also, we refered that statistical data analysis software operation (Unit root and co-integration)-EViews. Moreover, we dug out that eviews supply add in ARDL Bound approach.

#### UNIT ROOT (AUGMENTED DICKEY-FULLER TEST)

A. Trapletti explained Augmented Dickey-Fuller Test from Said and Dickey (1984), the matters are summarized as follows.

- 1. Description-Computes the Augmented Dickey-Fuller test for the null that x has a unit root.
- 2. Usage-adf.test(x, alternative = c("stationary", "explosive"),  $k = trunc((length(x)-1)^{(1/3)})$
- Arguments: x-a numeric vector or time series. Then, Alternative-indicates the alternative hypothesis and must be one of "stationary" (default) or "explosive". You can specify just the initial letter. Additional, k-the lag order to calculate the test statistic.

#### CO INTEGRATION

Cointegration is defined when the error term in the regression modeling is stationary. Cointegration has become an important property in contemporary time series analysis. Time series often have trends-either deterministic or stochastic. In a seminal paper, Charles Nelson and Charles Plosser (1982) pointed that most time series have stochastic trends-these are also called unit root processes, or processes integrated of order 1. Similarly, if two or more series are individually integrated (in the time series sense) but some linear combination of them has a lower order of integration, then the series are said to be cointegrated.

#### **GRANGER CAUSAL**

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another, first proposed in 1969(Granger, 1969). Ordinarily, regressions reflect "mere" correlations, but Clive Granger argued that causality in economics could be tested for by measuring the ability to predict the future values of a time series using prior values of another time series. Namely, a variable X that evolves over time Granger causes another evolving variable Y if predictions of the value of Y based on its own past values and on the past values of X are better than predictions of Y based only on its own past values.

#### **AUTOREGRESSIVE DISTRIBUTED LAG MODEL**

Tarverdi M Yashar (2014) made the ardlbound program, that described ARDL bound locates the best lag structure for an ARDL model. It also enforces the Wald test and finds the F-value required for ARDL bound test. Then, the program goes through following steps:

- 1. Check the variables to be time series.
- 2. Check the series to be stationary (This method (bound test) is applicable to time series which become stationary after taking maximum two differences.)
- 3. Based on the selected max lag, this add-in estimate an ECM with all lag combination possible. The equation is  $\Delta y_t = \beta_0 + \theta_0 y_{t-1} + \theta_1 x_{t-1} + \sum \beta_i \Delta y_{t-j} + \sum \alpha_i \Delta x_{t-j}$
- 4. Based on selected criterion, it highlights the "best" lag combination along with the F-value from Wald test (This F-value is required for comparison with tables in Pesaran et al (2001)).
- 5. At the end a table is presented. And the line that delivers satisfactory criterion is colored in Red. Also, the other criterion that might be satisfactory becomes orange.

#### THE EMPIRICAL RESULTS

#### UNIT ROOT

Unit root's Concept is if the root unit (non-stationary state) would be the difference, until the stationary state so far and we take advantage of Augmented Dickey-Fuller test. ADF unit root test had three models, as shown table 1, and ADF test was the T statistic, figures in brackets are through AIC to select the best lagged difference.

**TABLE 1: AUGMENTED DICKEY-FULLER EQUATIONS** 

Model	Equation	
Individual intercept and trend	$\Delta y_{t} = \alpha_{0} + \alpha_{2}t + \gamma y_{t-1} + \sum_{i=1} \beta_{i} \Delta y_{t-i} + \varepsilon_{t}$	(1)
Individual intercept	$\Delta y_{t} = \alpha_{0} + \gamma y_{t-1} + \sum_{i=1} \beta_{i} \Delta y_{t-i} + \varepsilon_{t}$	(2)
None	$\Delta y_{t} = \gamma y_{t-1} + \sum_{i=1}^{t} \beta_{i} \Delta y_{t-i} + \varepsilon_{t}$	(3)

Table 2 exhibits that individual intercept and trend has 4 significant (R, CA, IA, LA); Individual intercept has 2 significant (CA, MB); none has 2 significant (MB, LA). As a result, as Dickey-Fuller test statistic cannot reject unit root null hypothesis, therefore, make a further order differential test.

**TABLE 2: AUGMENTED DICKEY-FULLER LEVEL** 

Level	Individual intercept and trend	Individual intercept	None
R	-3.88994 ** (4)	-0.305324 (6)	2.190375 (6)
CA	-3.251994 * (0)	-2.980502 ** (0)	0.342361 (2)
PA	-1.536309 (0)	-1.590768 (0)	-0.764772 (0)
TA	-3.137485 (4)	-1.027872 (2)	0.592828 (2)
MB	-3.239094 (5)	-4.815285 *** (5)	-1.649433 * (2)
MC	-1.870175 (0)	-1.622825 (0)	0.167285 (0)
SB	-2.964479 (0)	-1.420633 (0)	0.048298 (0)
IA	-5.394028 *** (0)	-1.933162 (1)	0.927804 (2)
LA	-4.277384 ** (5)	-2.355575 (2)	-3.066371 *** (6)

Noted 1. \*, \*\*, \*\*\* connote 10%, 5% and 1% significant level.

Noted 2. () connotes numbers of Lags.

Noted 3. R: operating revenue, CA: BB ratio, PA: EPI, TA: Export order, MB: Rediscount Rate, MC: exchange rate, SB: Taiwan weighed stock index, IA: foreign direct investment, LA: unemployment rate.

Table 3 illustrates that nine variables in this study make a first-order differential test. After the first-order differential, known statistic can reject the null hypothesis of unit root, p-value is very small, evinces R, CA, PA, MB, MC, SB, IA, LA variables stationary state (No unit root). Moreover, TA variables in this study need to make a further order differential test, due to no significant in Individual intercept and trend, in a similar way, make a second-order differential test. After the second-order differential, known statistic can reject the null hypothesis of unit root, p-value is very small, announces TA variables stationary state (No unit root).

TABLE 3: AUGMENTED DICKEY-FULLER 1ND DIFFERENCE AND 2ND DIFFERENCE

1nd difference	Individual intercept and trend	Individual intercept	None
R	-3.299288 * (5)	-3.471455 ** (5)	-2.041303 ** (4)
CA	-5.867735 *** (2)	-5.955995 *** (2)	-6.015400 *** (2)
PA	-3.760454 ** (0)	-3.843555 *** (0)	-3.798749 *** (0)
TA	-3.038648 (3)	-2.767210 * (3)	-2.202692 ** (3)
MB	-3.555573 * (1)	-3.422259 ** (1)	-3.387417 *** (0)
MC	-5.219539 *** (3)	-4.599221 *** (0)	-4.680939 *** (0)
SB	-3.587608 * (0)	-3.660048 ** (0)	-3.698514 *** (0)
IA	-6.967955 *** (1)	-6.528111 *** (1)	-6.455502 *** (1)
LA	-4.572182 *** (5)	-4.157576 *** (5)	-2.631251 ** (5)
2nd difference			
TA	-6.569387 *** (2)	-6.435239 *** (2)	-6.682825 *** (2)

Noted 1. \*, \*\*, \*\*\* reveal 10%, 5% and 1% significant level.

Noted 2. () externalizes numbers of Lags.

Noted 3. R: operating revenue, CA: BB ratio, PA: EPI, TA: Export order, MB: Rediscount Rate, MC: exchange rate, SB: Taiwan weighed stock index, IA: foreign direct investment, LA: unemployment rate.

#### **CO-INTEGRATION TEST**

Using EViews software, the nine variables as group, then make equation and make residual series. We took residual series, view the unit root test, that pick out ADF, level and none, we gain reject the null hypothesis of no Cointegration. In cointegration of the analysis results, if there is cointegration relations between nine variables, that is to say nine variable had a long-term and stable relationship, declares as table 4.

**TABLE 4: RESID01** 

	t-Statistic	Prob.*	
Augmented Dickey-Fuller	-2.77659	0.0077 ***	
	1% level	-2.66936	
Test critical values:	5% level	-1.95641	
	10% level	-1.6085	

Noted 1. \*, \*\*, \*\*\* present 10%, 5% and 1% significant level.

#### **GRANGER CAUSAL**

Table 5 acquires the results as bellow.

- 1. We rejected Null Hypothesis at the 10% significant level, the results are one-way causal relationship as follows. CA: BB ratio will affect R: operating revenue. PA: EPI will affect CA: BB ratio, TA: Export order.
- 2. We reject Null Hypothesis at the 5% significant level, the results are one-way causal relationship as follows. SB: Taiwan weighed stock index, IA: foreign direct investment will affect R: operating revenue. TA: Export order, LA: unemployment rate will affect CA: BB ratio. MC: exchange rate will affect PA: EPI, and then PA: EPI will affect LA: unemployment rate. MB: Rediscount Rate, MC: exchange rate, SB: Taiwan weighed stock index will affect TA: Export order. MB: Rediscount Rate will affect SB: Taiwan weighed stock index.
- 3. We know Null Hypothesis result, there is one-way causal relationship at the 1% significant level, TA: Export order will affect R: operating revenue, LA: unemployment rate. MB: Rediscount Rate will affect CA: BB ratio, PA: EPI, LA: unemployment rate. SB: Taiwan weighed stock index will affect LA: unemployment rate.
- 4. Furthermore, SB: Taiwan weighed stock index and PA: EPI are bidirectional causality at the 10% significant level. MC: exchange rate and MB: Rediscount Rate are bidirectional causality, but MC: exchange rate will affect MB: Rediscount Rate at the 10% significant level, MB: Rediscount Rate will affect MC: exchange rate at the 5% significant level. No significant causal relationship between other variables.

**TABLE 5: PAIRWISE GRANGER CAUSALITY, LAG (2)** 

F-Statistic	R	CA	PA	TA	MB	MC	SB	IA	LA
R		3.32369*	0.89154	6.08850***	1.37127	1.90991	3.67269**	5.06124**	1.98716
CA	1.31093		2.99775*	5.19529**	6.93053***	0.1746	2.23766	0.15518	3.87616**
PA	0.29112	0.24595		2.086	8.92029***	5.04355**	2.90651*	1.17081	1.79821
TA	0.5551	2.01472	3.34256*		4.40814**	3.44561***	4.51661**	0.24391	0.49961
MB	0.22022	0.11431	1.96702	0.68545		3.03813*	2.1541	0.30033	2.31868
MC	0.77773	0.9425	0.86199	0.91344	5.35279**		1.8453	0.58204	1.58307
SB	1.60203	0.55311	4.86728*	1.91271	5.03136**	1.2983		2.3072	0.15054
IA	0.13134	1.45805	0.26573	0.59858	0.36907	0.62775	1.97463		0.955
LA	1.4508	1.08871	3.96513**	13.6612***	17.7698***	1.81415	8.40717***	0.82823	

Noted 1. \*\*\* represents rejected the null hypothesis at 1% significant level; \*\* expresses rejected the null hypothesis at 5% significant level; \* presents rejected the null hypothesis at 10% significant level.

Noted 2. R: operating revenue, CA: BB ratio, PA: EPI, TA: Export order, MB: Rediscount Rate, MC: exchange rate, SB: Taiwan weighed stock index, IA: foreign direct investment, LA: unemployment rate.

#### **AUTOREGRESSIVE DISTRIBUTED LAG MODEL**

If the sample size is too small, then the results will not be reliable and one should engrain Auto Regressive Distributed Lags (ARDL). Often, all possible combinations are considered and we select the one that results in the lowest AIC/SC value. These criteria are in the light of the high likelihood value. Wald test statistic is asymptotically chi-square, we choose significant. Due to foreign direct investment only affect operating revenue via Granger Causality test, we remove it and elect operating revenue, BB ratio, EPI, Export order, Rediscount Rate, exchange rate, Taiwan weighed stock index, unemployment rate to do ARDL.

Therefore, ARDL Model ran a total of 256 combinations, which ARDL (2,2,2,2,2,2,2) was best, due to AIC of 17.35122, SC of 18.56093, was among the smallest; and Log likelihood of -200.5659 was among the largest, demonstrates as table 6. Anyway, Wald test F value of 19,841.38 was significant at the 1% level.

TABLE 6: ARDL MODEL						
ARDL Model	AIC	SC	Log likelihood	F Wald test	P of Wald test	
ARDL(1,2,2,2,2,2,1,2)	23.62486	24.73779	-284.1232	243.4913	0.0004 ***	
ARDL(1,2,2,2,2,2,2,2)	23.3236	24.48492	-279.2068	236.5653	0.0042 ***	
ARDL(2,1,1,2,2,1,2,2)	22.21219	23.27673	-266.7585	1312.503	0.0000 ***	
ARDL(2,1,1,2,2,2,1,2)	23.17304	24.23758	-279.2495	410.3672	0.0000 ***	
ARDL(2,1,1,2,2,2,2,2)	22.04817	23.1611	-263.6262	1024.382	0.0000 ***	
ARDL(2,1,2,2,2,1,2,2)	22.28708	23.40001	-266.732	806.3831	0.0001 ***	
ARDL(2,1,2,2,2,2,1,2)	23.12639	24.23933	-277.6431	310.9409	0.0003 ***	
ARDL(2,1,2,2,2,2,2,2)	22.03898	23.2003	-262.5068	663.8777	0.0015 ***	
ARDL(2,2,1,2,2,1,1,2)	23.8531	24.91764	-288.0902	253.3836	0.0000 ***	
ARDL(2,2,1,2,2,1,2,2)	22.24199	23.35492	-266.1459	957.395	0.0001 ***	
ARDL(2,2,1,2,2,2,1,2)	22.88726	24.00019	-274.5344	315.6313	0.0003 ***	
ARDL(2,2,1,2,2,2,2,2)	21.89288	23.0542	-260.6074	603.1198	0.0017 ***	
ARDL(2,2,2,1,2,1,1,2)	23.84525	24.9098	-287.9883	230.2176	0.0000 ***	
ARDL(2,2,2,1,2,1,2,2)	23.73683	24.84977	-285.5788	206.5773	0.0005 ***	
ARDL(2,2,2,1,2,2,1,2)	23.88182	24.99476	-287.4637	150.725	0.0008 ***	
ARDL(2,2,2,1,2,2,2,2)	23.05454	24.21586	-275.709	247.1207	0.0040 ***	
ARDL(2,2,2,2,2,1,1,2)	23.6093	24.72223	-283.9209	181.1255	0.0006 ***	
ARDL(2,2,2,2,2,1,2,2)	22.22046	23.38178	-264.866	457.1046	0.0022 ***	
ARDL(2,2,2,2,2,2,1,2)	19.88539	21.04671	-234.51	3104.059	0.0003 ***	
ARDL(2,2,2,2,2,2,2,1)	23.41004	24.57136	-280.3306	131.9465	0.0075 ***	
ARDL(2,2,2,2,2,2,2,2)	17.35122	18.56093	-200.5659	19841.38	0.0055 ***	

Noted 1. \*\*\* at 1% significant level; \*\* at 5% significant level; \* at 10% significant level.

#### CONCLUSIONS

Through empirical analysis, and then summarized the following conclusions:

- 1. Augmented Dickey-Fuller test, finding that operating revenue, North American semiconductor book-to-bill ratio, Export Price Index, Export order, Rediscount Rate, exchange rate, Taiwan weighed stock index, foreign direct investment, unemployment rate,8 variables stationary state (No unit root) at first-order differential; Export order variables stationary state (No unit root) at first-order differential.
- 2. Nine variables carry out co-integration, we bring to light that reject the null hypothesis, clarify nine variable had a long-term and stable relationship.
- 3. Granger Causal results are Bidirectional causality, which are Taiwan weighed stock index vs EPI and exchange rate vs Rediscount Rate.
- 4. Granger Causal result is one-way causal relationship as follows.BB ratio will affect operating revenue. EPI will affect BB ratio and Export order. Taiwan weighed stock index, foreign direct investment will affect operating revenue. Export order and unemployment rate will affect BB ratio. Exchange rate will affect EPI, then EPI will affect unemployment rate. Rediscount Rate, exchange rate, Taiwan weighed stock index will affect Export order. Rediscount Rate will affect Taiwan weighed stock index. Export order will affect operating revenue, unemployment rate. Rediscount Rate will affect BB ratio, EPI, unemployment rate. Taiwan weighed stock index will affect unemployment rate.
- 5. ARDL Model ran a total of 256 combinations, which ARDL (2,2,2,2,2,2,2,2) was best.

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