Taiwanese Outward Investment: Economic Bane or Boon?

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Abstract

The magnitude and the rate of growth of outward investment from advanced to emerging economies has raised concerns among policy makers and economists around the globe. The concern is that capital outflows might lead to a reduction in domestic aggregate output and employment, place downward pressures on wages, especially for unskilled labor, or/and lower the rate of domestic capital deepening. These concerns threaten to induce policy change that might limit investment going abroad. However, counter evidence of beneficial effects of outward investment on technological advancement had also been established in the literature. This raises the general question this study will address: what is the nature of the economic process between outward investment and economic performance. The research interests here focus on empirically investigating, using time series data, the nature of the relationship between outward investment and productive capacity, i.e. GDP, for the home economy that provides outward investment. Contrast to the conventional belief, the econometric results indicate a persistent positive lagged effects of outward investment on GDP growth despite the downward pressure on domestic employment imposed by outward investment. These results are robust to various model specification and estimation methods for both annual and quaterly data. Adopting the concept of Granger causality, the results further indicate the causal relationship from outward investment to GDP for the case of Taiwan from 1981 to 2005. These findings challenge the negative perceptions upon which conservative policies discouraging outward investment are based and call for future research focusing on how these positive effects of outward investment on GDP are realized in the home economy.

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1 Introduction

Outward foreign direct investment[1] is relatively unique to countries at higher levels of income. As Taiwan transformed from an agriculture-based economy with \$150 per capita GNP to one of the top 25^{th} economies in the world with a $\$23,000$ per capital GNP over last 4 decades, outward investment gradually became more common among Taiwanese firms. The total outward investment (or outward foreign direct investment, OFDI) in 1981 was about \$105 million in 2001 U.S. dollars, which is less than 0.2% of GDP. The scale of outward investment soared in the mid 1980s, and now amounts to about 6 billion dollars (in 2001 U.S. dollars), about 2% of GDP. Since 1988, Taiwan became a net provider, rather than a net recipient, of foreign direct investment (FDI).

The magnitude and the rate of growth of outward investment has raised concerns among policy makers and economists. The concern is that capital outflows might lead to a reduction in domestic aggregate output and employment, place downward pressures on wages, especially for unskilled labor, or/and lower the rate of domestic capital deepening. In spite of the concerns, the country has continued to experience relative high rates of growth in real GDP per capita[2]. This raises the general question this study will address: what is the nature of the economic process that has allowed Taiwan to continue to experience strong economic growth while at the same time experiencing relatively large outward investment? Or, as a counter factual, would the country have experienced even more phenomenal growth if capital outflow had not occurred at such magnitude and speed?

Despite the negative general perception, the role of outward investment as a "constructive destruction" or restructuring force for the home economy is well documented in the literature, and especially so for the case of Japan. Outward investment has been viewed as a strategic choice by firms to exploit the much more integrated global market for inputs and hence to benefit through the increased efficiency and reduced costs. Conflicting findings leave the literature inconclusive on the role of outward investment in the growth paths of home economies.

The mixed perceptions of the effects of outward investment on home economies have inspired much past research and economists have had different views of how to approach the problem. The current research focuses on the relationship between outward investment and the macroeconomic environment in the countries that provided foreign direct investment (i.e. home countries). From the literature, there are various aspects of the macro-environment perceived to closely interact with outward investment. These aspects, namely employment, wage, investment, exports, and output levels, are all worthy research interests. In this

[1] The definition of foreign direct investment (FDI) varies. The most commonly used definition is first provided by IMF based on the ideas of lasting interest and influence on management. The lasting interest implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence on the management of the enterprise. This study adopts the definition of FDI from the Investment Commission, Ministry of Economic Affairs, Taiwan, which follows the provided definition closely.

[2] The average annual growth rate in GDP since 2002 is about 6%.

study, the focus is on the most direct measure of economic performance, output levels or production capacity (i.e. GDP), of an economy. Also, differing from the majority of the past studies, a country is the unit of research interests in this study, instead of a single firm.

This study investigates empirically, using time series data, the nature of the relationship between outward investment and output for the home economy. It is crucial for the relationship between outward investment and output performance to be identified to offer an empirical basis for policy guidance and future structural modeling efforts. This analysis estimates the primal production function in a simultaneous system to examine the linkage between outward investment and the evolution of GDP for the case of Taiwan. The estimation results indicate a persistent positive lagged effects of outward investment on GDP growth despite the observed downward pressure outward investment imposes on domestic employment. The causal linkage is further inspected with the concept of Granger causality. The results indicate outward investment Granger causes GDP for the case of Taiwan from 1981 to 2005.

Taiwan is a particularly interesting country upon which to base this analysis for several reasons. Taiwan's experience facing the emergence of China, with a similar culture, a large domestic market, and low cost labor, as a major competitor in both production of labor intensive goods and capital is very unique and interesting. Has Taiwan utilized the internationally integrated capital market to successfully compete with the emerging "new tigers" in the global market? Or has it experienced a slower growth path compared to if it had not been exposed to the international competition for capital? Because of the conservative policies towards foreign investment, outward and inward, data on foreign investment are carefully collected and maintained by Taiwanese government. The unique availability of data on foreign investment is a great advantage for this research.

This study differs from the majority of past studies in four key ways. First, rather than implying macro effects from micro evidence, this study approaches the effects of outward investment directly from a macro perspective. Second, though GDP (or output) is undeniably the most direct measure of economic performance, little had been done on its relationship with outward investment and this study adds onto the limited literature. Third, the utilization of time-series data and methodologies grants this research the ability to determine the nature of the linkage and ultimately the capability to investigate causality. Although often claimed, causality is seldom tested, let alone proved, in past studies and this study contributes to the literature by offering better understanding on he causal relationship between outward investment and GDP. Fourth, while past studies adopt various proxies, such as affiliate sales, for foreign direct investment, this study enjoys the advantage of data availability.

This paper is organized as the following. The next section provides background information on the history of outward investment in Taiwan, reviews selected past research on foreign investment, and discusses the hypotheses relating outward investment and the evolution of GDP. The data used for the subsequent analysis and their sources are briefly overviewed in the data section. Econometric methodologies adopted in the study are summarized and

their results reported in the following sections.

2 Conceptualizing the Problem

Before 1986, the amount of outward investment originated from Taiwan was a trivial quantity. The amount of outflowing investment took off after 1986 and peaked at the year of 1989, coinciding with the deregulation of capital movements across the Taiwan strait into China. After 1989, the amount of outward investment returned to the historical steady upward trend with dips corresponding to the 1997 Asian financial crisis and the 2001 downturn induced by the unfortunate 911 event. The steady upward trend is also observed in the amount of inward foreign investment. Only that inward investment seems to be to more responsive to shocks and hence the deeper dips immediately after 1997 and 2001.[3] Taiwan became and remains a net provider of foreign investment since the year of 1988. The average annual growth rate in outward investment was about 72% from 1981 to 2005. The importance of outward investment in GDP rose from less .1% to an average 2% since the mid 1980s. Figure 1 and 2 display the amount of outward and inward foreign investment and selected macro aggregates in Taiwan from 1981 to 2005 in constant 2001 Million U.S. dollars.[4]

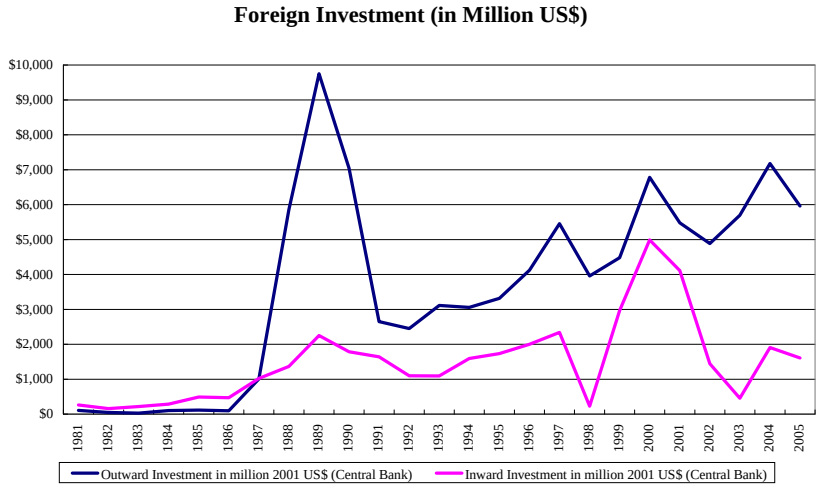

Figure 1

[3] Similar patterns in the quarterly data are also found. Please see Appendix for more Figures.

[4] Data source: Central Bank and Dgbas, Taiwan.

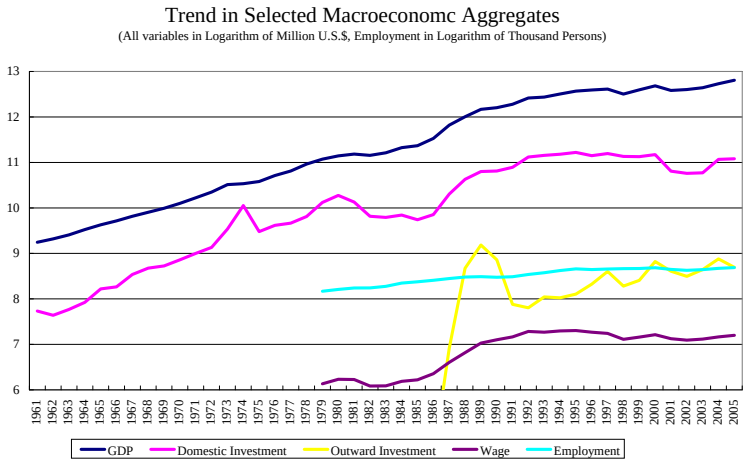

Figure 2

The global phenomenon of outward investment had attracted many researchers to ask why outward investment occurs. The ideas of "product cycle" (which is associated with the standardization of the production and cost-driven location decision), "firm-specific intangible assets," and "multi-plant scale economy" all contribute to our understanding of why firms engage in foreign investment activities. (Vernon (1966) and Caves (1974))

However interesting this "why" question is, this study looks beyond the micro strategic reasoning. It is far more interesting in our minds to understand how important the phenomenon is when firms, for whatever reasons, decide to engage in foreign investment activities. What are the effects, if any, of outward investment on the growth path of home economies? While outward investment roared 6000% for the past 25 years, income(output), employment, wage, and domestic investment had also increased quite steadily. The average annual growth rate for GDP was at 7%, employment at 2%, wage at 5%, and domestic investment at 6% over the same period. Although this shared upward trend can not be concluded as supports for the beneficial effects of outward investment, the alleged harmful impacts of outward investment on home economy are at least equally, if not more, concealed.

2.1 Literature Review

From the micro perspectives, Blomström (2000), Blomström & Lipsey (1997), Chen & Yang (1999), and Chen & Ku (2000) among others are examples in the

rich literature that aim to identify the impacts of outward investment on employment levels, wage, or sale growth in the investing firms. On the employment effects of outward investment, Blomström et al (1997), with descriptive regression techniques, found a negative relationship between the employment levels in U.S. multinational firms and the sales of their foreign affiliates in less developed countries. The negative relationship was also found between the "white-collar" employment levels and foreign affiliates sale for Swedish multinational firms. The relationship however is found to be positive between "blue-collar" employment levels and foreign affiliates sales for Swedish multinationals. Chen & Ku (2000) found that Taiwanese top ranking multinational manufacturers engaging in outward investment activities had higher survival rate and higher growth in sales. Although the authors claimed implications from the micro effects to the macro effects, there seems to be no support for the claim. The micro findings from country-specific outward investment experiences seem to provide conflicting conclusions.

The literature offers much more limited findings on the macroeconomic home economy effects of outward investment. Ozawa (1991), Kojima (1971), and Chen & Chen (1995) are of the most relevance. Ozawa (1991) in his famous work summarized the Japanese history of outward investment experiences and observed the persistent ability of the economy to transform itself and grow. His view of outward investment as a "critical agent of industrial restructuring" for its "house-cleaning-and-renovating" function, which he believed had helped the Japanese economy to upgrade its industrial structure continually. Ozawa's view differs greatly from the widespread fear of "hollowing-out" effects of the alleged export-substituting outward investment at his time and offered a new angle for economists to conceptualize the macro effects of outward investment. Kojima (1971) and Chen & Chen (1995) both categorized outward investment by its purposes, assumed to be revealed through its destination. The distinction is between the "cost-oriented" defensive outward investment and the "market-oriented" expansionary outward investment. Clearly from the names, the distinction was made for the purposes of the outward investment: expansionary investment for the expansion of the firms and defensive investment are for the survival of the firms. Researchers proposed purposes of expansionary outward investment as to exploit firms' specific advantages and scale economy, to secure production resources, or to avert risks by investing abroad. Expansionary investment are usually associated with larger enterprises and the integration style tends to be vertical. This type of outward investment is often considered benign in the literature, if not beneficial, to the home economy with supporting micro evidence at the firm level. The purposes of defensive outward investment are cited in literature as mostly for cost reduction and maintaining of market share. This type of investment is usually associated with small enterprises in industries losing comparative advantage, concentration in countries with abundant inexpensive labor, and horizontal integration in the production process. In practice, the distinction was usually made according to the destination of the investment despite conceptual distinctions suggested by researchers. The outward investment destined for high wage countries is classified as expansionary and outward

investment for low wage countries defensive. The categorization of outward investment, no matter by their destinations, purposes, or other characteristics may be helpful in identifying the macro effects of outward investment which may be otherwise masked. Chen & Chen (1995) attempted to show the alleged beneficial effects of expansionary outward investment and the alleged harmful effects, or "deindustrialization" effects, of defensive outward investment on Taiwanese manufacturing industry. The claimed supporting results were unclear in the study.

Overall, the literature offers mixed conclusions and little evidence on the macro effects of outward investment on the home economy. This in part motivates this study.

2.2 Existing Hypotheses

Responding to the limited literature, this study intends to answer the "how important" question by focusing on the relationship between outward investment and the most direct measure of home economic performance, the growth path of GDP. Conceptually, outward investment does not directly impact output levels since it is not a part of the domestic production function. If outward investment has an impact on the level of output, it is indirectly through its effects on inputs. Past research hypotheses from the literature serve as a departure point to formulate our beliefs of the possible indirect effects of outward investment on output levels.

Replacement effects on domestic labor demand If foreign production is a superior strategy to domestic production for firms, outward investment reduce the demand for domestic labor. The aggregate macro effects of outward investment on home country employment are expected to be negative. Consequently, the indirect impacts of outward investment on output through reduced employment levels are expected to be negative.

Competition against domestic investment Stevens & Lipsey (1992) argued the strong interactions among firms' decisions on investing domestic or abroad. The authors believe expenditures in different locations compete for funds at the firm level. If outward foreign and domestic investment compete for the same financing sources, there expect to be substitution effects between them. Braunerhjelm and Oxelheim (2000) examed whether there are "substitutionary" effects of outward investment on domestic investment in Swedish industries. They found conflicting results for traditional or R&D-intensive industries in Sweden and claimed that the effects are industry specific. Despite the mixed evidence, the hypothesized competition or sustitution between outward and domestic investment is commonly embraced in the literature. If that is true, the levels of outward investment are expected to be negatively related to the levels of domestic investment. The indirect impacts of outward investment on output through reduced domestic capital deepening are then expected to be negative.

Upgrading force From the Japanese experiences (Ozawa (1991)), outward investment activities force home economy to upgrade its industry structure and improve its productivity. Ku (1998) also found higher levels of industry restructuring in firms that had engaged outward investment in his analysis of Taiwanese firms in electronic industry. As often suggested in the corporate world, fierce competition often rouses improvement in productivity for survival. If the global competition further realized through the increasingly integrated international capital market works in a parallel fashion, outward investment is expected to stimulate productivity growth in domestic industries. Its impacts on output levels are therefore expected to be positive through higher efficiency.

More efficient global division of inputs Outward investment, as often suggested in the literature, is one of firms' strategies to exploit the ever integrating global markets for inputs. Strong connections among foreign affiliates or subsidiaries and their parent firms was suggested by the Taiwanese literature. Liu and Lin (2001) summarized that about 1/3 of the Taiwanese firms engaging outward investment resell their products back to Taiwan. Among those foreign affiliates or subsidiaries, the share of sales to Taiwanese market averaged about 40% of their total sales. The highest of this share exists in investing firms who engage in vertical integration in production. That is firms who invest in foreign production that belongs to the same chain of production as in the domestic production, have higher shares of sales sold back to Taiwan. Evidence from Taiwan seem to suggest a scenario where firms engaging outward investment to produce abroad and importing back their foreign output to the home economy. This has two implications. First, consumers enjoy cheaper prices if these products are final consumption goods. Second, if these products are imported back and used as intermediate inputs, firms enjoy lower input prices and hence an output boost. The implication of the second situation for the current study is conspicuous. In this case, the indirect impacts of outward investment on output are expected to be positive through the lower costs of intermediate inputs.[5]

Although these hypotheses pose greatly different expectations on the effects of outward investment, they may not be mutually exclusive from one another. These hypotheses may fit the experiences of some sectors better than others at a less aggregate level of the home economy[6]. It is also possible that outward investment may have offsetting effects on the aggregate home economy as suggested by the hypotheses. Outward investment may impose downward pressure on domestic employment, but at the same time induce productivity growth. It is of vital importance for these hypotheses to own empirical foundations. Our analysis first seeks to determine the sign of the relationship between

[5] Although interesting, the reasons for why firms prefer investing foreign production instead of importing intermediate input supply are not the focus of the paper. The goal here is to investigate whether this micro strategy leads to positive effects of outward investment on output at the macro level.

[6] If data permits, the relationship between outward investment and output can be investigated at a less aggregate level to uncover the possibility of winning and losing industries in the effects of outward investment.

outward investment and output levels. If the hypotheses are mutually exclusive, the estimated sign of the association evidently fits only some of the hypotheses. More likely, this estimated sign will reveal the net impacts of outward investment on output at the aggregate level if the hypotheses are not mutually exclusive. Nevertheless, the discovery of the sign of the relationship between outward investment and output levels will greatly improve our understanding of the problem and benefit the sequential modeling efforts.

It is also sensible to believe that different types of outward investment have dissimilar impacts on the home economy as suggested in the literature. The effects of the two types, namely expansionary and defensive, outward investment can be estimated separately to uncover the possible distinct effects of outward investment.

3 Methodology

To investigate the effects of outward investment and output evolution in the Taiwanese economy, the output function is estimated with relevant input factors controlled. Let the aggregate production be expressed as a function of factors employments, including labor, capital, intermediate inputs, productivity, and some external shocks.

$$Y_t = F(K_t, L_t, H_t, X_t) \cdot A_t$$

where K_t is the capital stock at time t, L_t represents the labor inputs employed over time period t, H_t stands for human capital for workers at time t, X_t represents the intermediate inputs employed during time period t, and A_t is the productivity index at time t and external shocks are assumed to be embedded in the productivity index.

In the neoclassical world, capital accumulation is assumed to be governed by a law of motion which equates the current capital stock as the depreciated lag capital stock and investment.[7] Iteratively, the current capital stock can be written as the sum of a sequence of net investment and the initial capital stock.[8] Although the additive effects of investment on capital stock accumulation were assumed here, it needs not be the case of how we quantify the influence of

[7] The assumed form of motion equation here is:

$$K_t = \dot{K}_{t-1} + (1-d)K_{t-1}$$

, where d is the depreciation rate for a unit of period and $\dot{K}_{t-1}$ is the flow or increment of capital at time $t-1$, from the last period.

[8]

$$\begin{aligned} K_t &= \dot{K}_{t-1} + (1-d)\dot{K}_{t-2} + (1-d)^2\dot{K}_{t-3} + ... \\ &\quad +(1-d)^{t-1}\dot{K}_1 + (1-d)^t K_0 \\ &= \sum_{i=0}^{t-1}(1-d)^i \dot{K}_{t-1-i} + (1-d)^t K_0 \end{aligned}$$

investment on capital stock. Relaxing the form of the function, let's just state that the current capital stock can be expressed as function of a series of past investment and initial capital stock. The output function can be written as:

$$Y_t = F(K_0, \{\dot{K}_{t-i}\}_{i=1}^{t-1}, L_t, H_t, X_t) \cdot A_t$$

which suggests that current level of output is a function of capital stock some periods ago, past values of capital flows (investment), current values of labor and intermediate inputs, and productivity. It is clear that the effects of outward investment don't directly enter the output function. As stated in the hypotheses, the impacts of outward investment are expected to be channeled through inputs or productivity. The effects of outward investment on productivity or inputs are very likely to be lagged. The economy needs time to respond to the impacts reduced by outward investment. Now, let's assume that X_t depends solely on past values of outward investment and A_t depends on past values of outward investment and time.

$$X_t = X(\{O_{t-i}\}_{i=1}^{l})$$

$$A_t = A(\{O_{t-i}\}_{i=1}^{l}, t)$$

, where O_{t-i} is outward investment occurred during time period $t-i$ for $i = 1, 2, 3, ...$ The output function can be expressed as:

$$Y_t = F(K_0, \{\dot{K}_{t-i}\}_{i=1}^{t-1}, L_t, H_t, \{O_{t-i}\}_{i=1}^{l}, t)$$

The most common problem of estimating direction output functions is that input factors may be endogenous and thus the direct estimators are biased and inconsistent. This is often called the simultaneous equation bias in the estimators. In our case, capital stock is estimated by an iterative process following the law of motion. Capital flows and stock from last period are determined previous to current output levels. Thus, these lagged variables are regarded as predetermined values and not endogeneous in the models.

In models where current capital stock (or investment) and employment are present, endogeneity in input variables is very likely. In practice, issues of endogeneity is often addressed with instrumental variables techniques, where K_t and L_t can be instrumented by the lagged values of themselves and other relevant exogenous variables.[9]

Moreover, given the nature of the problem, the relations between output and input variables can be modeled as a system of equations where all endogenous variables are estimated simultaneously. Suppose

$$\begin{aligned} Y_t &= F(K_0, \{\dot{K}_{t-i}\}_{i=1}^{t-1}, L_t, H_t, \{O_{t-i}\}_{i=1}^{l}, t) \text{.....} Eq1 \\ L_t &= L(Y_t, \{L_{t-i}\}_{i=1}^{p_L}, \{O_{t-i}\}_{i=1}^{l}) \text{.....} Eq2 \\ K_t &= K(Y_t, \{K_{t-i}\}_{i=1}^{p_K}, \{O_{t-i}\}_{i=1}^{l}, Z_t, t) \text{.....} Eq3 \end{aligned}$$

[9] The treatment of lagged terms of endogenous variables as predetermined values is discussed in endogeneity adjustment section.

where Z_t are other relevant exogenous variables that can serve as instruments additional to the lagged values of K_t. The system contains autoregressive employment and capital functions and an output function. The model determines the values of three endogenous variables, Y_t, K_t, and L_t. In addition to the exogenous variables, H_t, Z_t, and t, there are predetermined values, $\{K_{t-i}\}_{i=1}^{p_k}$, $\{O_{t-i}\}_{i=1}^{l}$, $\{L_{t-i}\}_{i=1}^{p_L}$, and $\{\dot{K}_{t-i}\}_{i=1}^{t-1}$ in the system. Although these lagged variables may not be completely exogenous, in practice, they are often regarded as already determined previous to the current values of the endogenous variables.[10]

The coefficients on lagged outward investment in $K_t = K(\cdot)$ and $L_t = L(\cdot)$ are expected to be negative as suggested by the hypotheses on effects of outward investment on inputs. The research interests here however center around the coefficients on $\{O_{t-i}\}_{i=1}^{l}$ in $Y_t = F(\cdot)$. What is this indirect relationship between outward investment and output? The sign of the coefficients on $\{O_{t-i}\}_{i=1}^{l}$ indicate the nature of the "net of inputs" relationship between outward investment and output. Positive coefficients on $\{O_{t-i}\}_{i=1}^{l}$ indicate the beneficial "net" effects of outward investment on output while negative coefficients indicate the baneful effects.

The detail derivation of the estimated equations is provided in the appendix. To avoid redundancy, detail derivation is reported only for the annual models. The choice of the lag terms in derivation and other details in estimation are provided in the following section.

4 Data

All the data are collected and maintained by various Taiwanese government agencies. Taiwanese regulation requires Taiwanese outward investment for China be reported and approved by the Investment Commission. Inward foreign investment is also required to be approved by the same agency. Although there are tax and other incentives, Taiwanese investment for countries other than China are not required to be reported or approved by the Investment Commission. The data reported by the Investment Commission is therefore expected to underestimate the true amount of outward investment to the rest of the world. Data prepared by the Investment Commission faces other limitations. The approved amount does not, and often is not, the final realized amount of investment. Although these investment data have proved to be reliable in past years, they are only used as an alternative data source in this study. Fortunately, the Taiwanese Central Bank records and reports transactions labeled as investment for foreign countries. Although not in as great detail, the central bank data are more reliable. Thus foreign investment data from Taiwanese Central Bank serve as the main source in out analysis. The availability of two series provides an opportunity to compare the two sources. The econometric models were estimated with both sources. The difference in results for the two sources is trivial in most cases. The final analysis on the aggregate level was done using the Central Bank data for its accuracy. The analysis at the sectoral

[10] More discussion in endogeneity adjustment section.

level and involving destinations of outward investment however were done using the Investment Commission data for its availability.

National income, domestic investment, employment, average years of schooling, exchange rates, and other macroeconomic data are provided by the Directorate General of Budget, Accounting and Statistics (DGBAS), Executive Yuan and is available at http://www.stat.gov.tw. The data on output, wage, and domestic investment are converted to U.S. dollars using published exchange rates to match the foreign investment data measured mainly in U.S. dollars. All the variables were in constant 2001 price.

The complete series on capital stock is calculated from limited capital stock data from National Wealth Survey and data on domestic and inward foreign investment. The computation follows the assumed capital accumulation relationship, $K_t = \dot{K}_{t-1} + (1-d)K_{t-1}$, among the stock and flows of capital. d is the depreciation rate for a unit of period and $\dot{K}_{t-1}$ is the flow or increment of capital at time $t-1$, from the last period. $\dot{K}_{t-1}$ consists of both domestic and inward foreign direct investment occurred in period $t-1$. The depreciation rate is suggested by data to be around 5% per annum.[11]

All the data are available on both annual and quarterly basis. Annual data is preferable for a couple of reasons. Data in shorter time interval, such as monthly and quarterly data, tend to have more "noise" than data in longer time interval. For instance, seasonality, or periodic fluctuations, in quarterly data is more likely to have no relevance for in explaining the relationship between output and outward investment, which is of research interests here. However, the presence of seasonality may considerably mask the relationship of interests and greatly complicate the task to extract useful information. Also, the possibility of measurement errors regarding to reporting time is higher with data in shorter time interval. It is more difficult to argue that the recording time of transactions don't always match the occurrences of the transactions in, say, the annual data. The draw back of annual data is the small sample size. For this the reason, the analysis is also done in quarterly data to show robustness of the results.

5 Estimation Details

5.1 Lag Length Selection

Although the theory provides us with relevant variables to consider, there are more issues in estimation that need to be addressed. Issues involving stationarity, proper length of lags, serially related residuals, seasonality, structural break, heteroscadesticity, and endogeneity, all may occur in this analysis. All of these issues are of great estimation importance and will be discussed in detail in the following sections.

Stationarity of the variables are checked utilizing the augmented Dickey-Fuller (ADF) unit root test.[12] With the stationized variables, the autocorre-

[11] Quarterly depreciation rate is calculated accordingly.

[12] The test results suggest, in logarithm form or not, annual GDP, domestic investment

lation functions (ACF), partial autocorrelation functions (PACF), and cross-autocorrelation functions (CCF)[13] provide information on how the current values of these variables are related to the past values of themselves or another variable.[14] Various autocorrelation functions are informative on the behavior of time series and provide guidance for lagged term selection.

For a variable that can be expressed as a function of past values of itself or others, it is undesirable to include all the past values in estimation for clear reasons such as over-parameterization. The long lagged values are also theoretically expected to have diminishing influence on the current value. In this study, A/PACF of the variables and CCF between the variables, and AIC(Akaike Information Criteria)[15] provide guidance throughout our econometric modeling efforts. The lag length is determined by minimizing BIC (Bayesian Information Criteria, also known as SBC (Schwarz Bayesian Criteria))[16] subject to the non-rejection of Q-test[17] and LM-test[18] for residual autocorrelation. With annual data, the maximum lag length considered is 4 years. From results, information criteria discourage lag length longer than two periods. With quarterly data, the maximum lag length is for 3 years or 12 lags. Different from the annual data, the selection of lag length has to account for seasonality in quarterly data. The selection criteria is still minimizing BIC subject to the non-rejection of Q-test

and employment are I(2) processes and outward and inward foreign investment being I(1) processes. Quarterly variables are all I(1) processes in logarithm or not. Lag length from 1 to 4 and types of a zero mean, a single mean, and a trend are all tried and the ADF test yield similar statistics.

[13] The CCFs estimate the correlation between one variable and the lag terms of the other.

[14] The high correlation at the current values between GDP and other explanatory variables confirms the theory's relevance empirically. The bivariate CCF also suggests that GDP leads outward investment, i.e. higher values of outputs this year is significantly and positively correlated with higher values of outward investment this year and next year. This finding is of course sensible since higher income leads to higher ability to invest, domestically or abroad. This also raises cautions to the inclusion of current value of outward investment in output estimation equation.

[15] Akaike (1974) suggested measuring the goodness of fit for models as: AIC=$\ln\left(\frac{RSS}{n}\right) + \frac{2k}{n} \simeq -2\ln(L_x)+2k$, where RSS is the residual sum of squares, k is the number of estimators, n is the number of observations, L_x is the estimated likelihood function. This is equilvalent as to maximize the esimated likelihood function with a panelty for additional estimators.

[16] Similarly to AIC, BIC=$\ln\left(\frac{RSS}{n}\right) + \frac{k\ln n}{n} \simeq -2\ln(L_x) + \frac{k\ln n}{2}$

[17] The Ljung-Box Q-Statistics is $Q = n(n+2)\sum_{j=1}^{m}\frac{\hat{\rho}^2(j)}{n-j} \to \chi^2_m$, where n is the sample size for residuals, $\hat{\rho}^2(j)$ is the estimated autocorrelation parameter between n^{th} and $(n-j)^{th}$ residual, m is the number of autocorrelations calculated. Q converges in distribution to a χ^2 distribution with m degrees of freedom. The test relies on if the residuals is a realizaton from a white noise process.

[18] The null hypothesis of Godfrey's (LM) test is that the equation residuals are white noise. However, if the equation includes autoregressive error model of order p (AR(p),) then the lag i test, when considered in terms of the structural error, is for the null hypothesis that the structural errors are from an AR(p) process versus the alternative hypothesis that the errors are from an AR($p+i$) process.

and LM-test for residual autocorrelation. The estimated results reported are for the lag length that yields best performance gauged by lag length selection criterion provided previously.

5.2 Seasonality in Quarterly Data

From various autocorrelation functions, the expected seasonality in quarterly variables is confirmed. Seasonality and other possible "noises" greatly complicate the estimation process with quarterly data. The literature suggests researchers away from using the seasonally adjusted data. The consensus in the literature is to model the seasonality directly with the now sophisticated time series techniques. (Sims(1974) and Bell & Hillmer(1984)) The rich literature offered numerous estimation techniques in dealing with seasonality in time series modeling. The choice of techniques depends greatly on the nature of the data and the research. For example, if the seasonality is deterministic and time invariant, simple seasonal dummies are sufficient in capturing the seasonal behavior in data series. More flexible models can allow time-varying or nonlinear seasonal behavior in series. (Franses and Dijk(2005), Harvey and Scott(1994), and Dijk et. al.(2003))

Majority of the techniques dealing with various forms of seasonality are designed for pure time series analysis, such as univariate ARIMA or VAR (vector autoregressive) models. This makes the application of these techniques less obvious in our case. The modeling efforts in this paper focus only on deterministic time-varying linear seasonality since recent literature document better forecasting unbiasedness and efficiency for simpler models compared to more complex models such as those deal with nonlinear seasonality. (Franses and Dijk(2005)) More specifically, seasonality is modeled by a vector of dummy variables capturing deterministic or time-varying seasonality.

$$
\begin{aligned}
q \quad = \quad & \{q_2, q_3, q_4\} \text{ or} \\
& \left\{ \begin{array}{c} q_2(G(t;c_1,c_2)), q_3(G(t;c_1,c_2)) \\ , q_4(G(t;c_1,c_2)), q_2(1-G(t;c_1,c_2)) \\ , q_3(1-G(t;c_1,c_2)), q_4(1-G(t;c_1,c_2)) \end{array} \right\}
\end{aligned}
$$

where q_i is the dummy variable represents the i^{th} quarter of the year, $G(t;c_1,c_2) = \frac{1}{1+\exp\{-c_1(t-c_2)\}}$ and c_1 and c_2 are parameters.

In addition, as expected, the univariate P/A/CCF results also show that lag terms multiplicative of 4 have more explanatory power over the current values of the quarterly variables. This observed empiric regularity is incorporated into the modeling of residual behavior and lagged terms.

5.3 Model Adjustment[19]

5.3.1 Endogeneity Adjustment

The estimated system contain three endogenous variables, Y_t, K_t, and L_t. Their lagged values and the lagged outward investment are treated as predetermined values and regarded as not endogenously determined in the system. Although current outward investment does not enter the equations, the degree of exogeneity of outward investment is worth paying some more attentions. The concept of Granger causality can help us further determine the degree of endogeneity of outward investment in the system. The idea of traditional Granger causality is that if the lagged values of B_t add no additional information to explain the variation in G_t beyond what is provided by lagged values of G_t. Then, by definition, B_t does not Granger cause G_t. Granger causality is absent if $f(G_t|\{G_{t-i}\}_{i=1}^{k}) = f(G_t|\{G_{t-i}\}_{i=1}^{k}, \{B_{t-i}\}_{i=1}^{k_1})$. The concept can be flexed to include additional variables. That is conditional Granger causality is absent if $f(G_t|\{G_{t-i}\}_{i=1}^{k}, \mathbf{M}_t) = f(G_t|\{G_{t-i}\}_{i=1}^{k}, \{B_{t-i}\}_{i=1}^{k_1}, \mathbf{M}_t)$ where $\mathbf{M}_t$ stands for a vector of additional variables that may hold explanatory ability over the variation in G_t.

Utilizing quarterly data on outward investment and GDP, the F-test results, reported in Table 1, cannot reject the null hypothesis that GDP does not Granger causes outward investment. Results however strongly suggest that outward investment Granger causes GDP for the case of Taiwan during the period from 1981 to 2005. Bivariate and conditional Granger tests[20] are also exercised with VAR estimation. Results offer the same evidence for unidirectional Granger causality originating from outward investment to GDP in the data analyzed. Similar tests are also conducted between outward investment and employment and capital stock. Results suggest the absence of Granger causality between outward investment and capital stock. Results are rather inconclusive on the causality relationship between outward investment and employment.

Findings from Granger causality tests alleviate the worries of endogenous outward investment. Lagged terms of outward investment are treated as exogenous in this analysis for their pre-determinedness and the weak endogeneity of outward investment in the system. The endogenous variables are estimated with both instrumented regression and simultaneous equation models using 3SLS (three stage least square) techniques and proper adjustment for residual autocorrelation.

[19] One additional model adjustment of possible structural breaks is checked and rejected by Chow test for all possible periods.

[20] The conditioning variables are growth rates in employment, capital stock, exchange rate, and time-varying or deterministic quarterly dummies.

Pairwise Granger Causality Tests in U.S.D. (Null Hypothesis)	Obs.	Lag.	F-Stat.	Prob.
OFDI does not Granger Cause GDP	98	1	8.90	0.00
	97	2	4.72	0.01
	96	3	4.82	0.00
	95	4	2.07	0.09
	94	5	1.80	0.12
	93	6	1.30	0.27
	92	7	1.14	0.35
	91	8	1.51	0.17
GDP does not Granger Cause OFDI	98	1	1.59	0.21
	97	2	0.53	0.59
	96	3	1.18	0.32
	95	4	0.20	0.94
	94	5	0.27	0.93
	93	6	0.28	0.95
	92	7	0.20	0.98
	91	8	0.18	0.99

Table 1

Most importantly, the idea of Granger causality affords evidence for causality that is otherwise not possible in regression analysis. Insights on the direction of the linkage greatly focus and facilitate the interpretations of estimation results.

5.3.2 Error Adjustment

Because of the time-series nature of the data at hand, the residuals from the estimated equations is very likely to be serial correlated and the ordinary least square (OLS) estimators will be biased in this case. The residuals are assumed to follow ARMA process. Let ε_t be the representative estimated residuals from estimated models.

$$\varepsilon_t = \phi_1\varepsilon_{t-1} + \phi_2\varepsilon_{t-2} + ... + \phi_p\varepsilon_{t-p} + w_t + \theta_1 w_{t-1} + \theta_2 w_{t-2} + ... + \theta_q w_{t-q}$$

Let the lag operators $\phi(B) = 1-\phi_1 B-\phi_2 B^2-...-\phi_p B^p$ be the autoregressive linear lag operator for ε_t and $\theta(B) = 1 + \theta_1 B + \theta_2 B^2 + ... + \theta_q B^q$ be the moving average linear operator for ε_t. w_t is a white noise process. The residuals behavior can be expressed as $\phi(B)\varepsilon_t = \theta(B)w_t$. With the adjustment of $\frac{\phi(B)}{\theta(B)}$ on the regression equation, residuals and variables, the adjusted residuals are now w_t and the estimators are expected to be unbiased estimators. Proper ARMA adjustment of residuals is determined with the assistance of various autocorrelation functions, the Q- and LM-test for residual autocorrelation, and the information criterion. The autoregressive structure is suggested to be the most appropriate to capture the error behavior in both annual and quarterly models.

Heteroscadesticity in residuals is checked and rejected by the Q-test[21] and LM-test[22] for all models with annual data. The heteroscadesticity in residuals in quarterly models is also rejected for unequal variances. For sensitivity and robustness check, the rejected unequal variance is still modeled by assuming residuals behave similarly to autoregressive conditional heteroskedasticity (ARCH) and general ARCH (GARCH) processes. Results confirm the robustness of the estimators.

5.4 Estimated Models

With assumptions on functional forms, the following estimated models are obtained after model derivation and lag selection process with annual data. In levels, the estimated model is:

$$\begin{aligned} \ln Y_t &= \gamma_{0k} + \gamma_{1k} \ln K_t + \gamma_{5k} \ln O_{t-2} \\ &\quad + \gamma_{6k} \ln L_t + \gamma_{7k} \ln S_t + \gamma_{8k} \cdot t + \gamma_{9k} \ln E_t + \epsilon_t^k \end{aligned}$$

Equivalently, the model can be estimated with growth rates in variables:

$$\begin{aligned} \Delta \ln Y_t &= \gamma_{8k} + \gamma_{1k} \Delta \ln K_t + \gamma_{5k} \Delta \ln O_{t-2} \\ &\quad + \gamma_{6k} \Delta \ln L_t + \gamma_{7k} \Delta \ln S_t + \gamma_{9k} \Delta \ln E_t + \Delta \epsilon_t^k \end{aligned}$$

Depending on research interests, capital stock can be accounted as past capital stock and flows. In other words, $\boldsymbol{\gamma}_{1k} \ln K_t$ can be equated to $\boldsymbol{\gamma}_{2k} \ln K_{t-1} + \boldsymbol{\gamma}_{3k} \ln D_{t-1} + \boldsymbol{\gamma}_{4k} \ln I_{t-1}$, where capital flows are D_{t-1}, the domestic investment, and I_{t-1}, the inward investment occurred during time period $t-1$.

With quarterly data, the estimated models are:

$$\begin{aligned} \ln Y_t &= \iota_0 + \iota_1 \ln K_t + \iota_5 \ln O_{t-3} + \iota_6 \ln L_t \\ &\quad + \iota_7 \ln S + \iota_8 \ln E_t + \boldsymbol{\iota}_9 \cdot \mathbf{q} + \iota_{10} \cdot t + \epsilon_t^q \end{aligned}$$

where $\mathbf{q}$ is a vector of deterministic quarter dummies or a vector of time-varying quarter dummies stated previously. Again, equivalently,

[21] This is the same Q-test mentioned previously. Only here it is apply to the squared residuals to test for the possible heteroscadesticity in the variance of residuals. The Q(i) statistic is computed from the OLS residuals assuming that disturbances are white noise. The Q(i) statistic has an approximate $\chi^2_{(i)}$ distribution under the white-noise null hypothesis.

[22] This Lagrange multiplier test for ARCH disturbances proposed by Engle (1982) is asymptotically equivalent to the test used by Breusch and Pagan (1979). The LM(i) statistic is computed from the OLS residuals assuming that disturbances are white noise. The LM(i) statistic has an approximate $\chi^2_{(i)}$ distribution under the white-noise null hypothesis.

$$\begin{aligned}\Delta \ln Y_t &= \iota_0 + \iota_1 \Delta \ln K_t + \iota_5 \Delta \ln O_{t-3} + \iota_6 \Delta \ln L_t \\ &\quad + \iota_7 \Delta \ln S + \iota_8 \Delta \ln E_t + \boldsymbol{\iota}_9 \cdot \mathbf{q} + \Delta \epsilon_t^q\end{aligned}$$

Variation in accounting for current capital stock also applies with quarterly models. Selected results are reported in the result section.

6 Empirical Results

The key equation is the output function mainly foucs on the coefficient on outward investment. Table 2 reports the estimation results for the output function with and without endogeneity adjustment. Results from the full system estimation is reported in Table 3 and 4. Although results of the system estimation provide deeper insights on the input - investment linkages,the main foucs here is on the relationship between outward investment on productive capacity, i.e. GDP.

6.1 Annual Results

In the first column of Table 2, a simple growth accounting like model is estimated. As expected, the coefficients on current capital stock, employment, and productivity advance are all positive and mostly statistically significant. With no surprises, current employment is the most dominant determinants of current output levels with an estimated elasticity .98. The estimated technical advance rate, coefficient on time, is about 3% in the reported model. This magnitude is consistent with the estimated level of TFP[23] in growth accounting literature for the covered period for Taiwan. The focal coefficient on outward investment is estimated to be .02, which suggests a positive effect of lagged outward investment on current output. The estimated elasticity on capital stock is surprisingly either lacking statistic significance or of trivial magnitude in all estimated models.

In the model reported in the second column, human capital measured as average years of schooling is included to account for the growth in skills over time. The negative estimated TFP effect after accounting for labor skills seems to suggest growth in technological advancement is closely linked to the growth in the stock of labor skills. Results show human capital accumulation is a dominant factor of output evolution.

Models reported in column 3 and 4 are designed to test the sensitivity of results to model alteration. Surprisingly, the results change little with the inclusion of lagged dependent variable and the exclusion of lagged outward investment. It indicates that the results are robust to model alteration. Column 5 to 7 report the instrumented single equation estimation and the simultaneous

[23] The coefficient on time estimates TFP (Total factor productivity).

equation estimation. The consistent sign, magnitude, and significance of the estimators further confirm the robustness and stability of the estimators.

The focal coefficients on outward investment, .02, suggests lagged two-year positive effects of outward investment on output. This estimated coefficient on outward investment are all in very narrow neighborhood of .02. The focal coefficient on lagged two year outward investment is robust in sign, magnitude, and significance against model alteration. The estimated effects of last year's outward investment are much less influential in comparison. The coefficients of last year's outward investment are of trivial magnitude and alternate in signs and significance levels, which indicates inconclusive results. Together, these results suggest longer lagged positive effects of outward investment on output in Taiwan for the covered period.

Estimation results are further tested for stability by estimating models with growth rates in variables and with variables measured in NT dollars. In all estimated models, the key coefficient on outward investment remain robust in sign, magnitude, and significance. Results are reported in Table 3 next and Table A1 in appendix.

Dependent Variable: Log GDP in Million 2001 U.S. Dollars							
Variables	Signle Equation				IV Estimation: Capital Stock		System Equations
Current Capital Stock	0.134	-0.112	-0.143	-0.137	-0.234	-0.163	-0.226
Lag Outward Foreign Investments			-0.004	-0.001			
Lag 2 period Outward Foreign Investments	0.016 **	0.019 ***	0.021 ***	0.024 ***	0.022 ***	0.023 ***	0.021 ***
Current Employment	0.987 ***	1.042 ***	1.044 ***	1.114 ***	1.128 ***	1.148 ***	1.167 ***
Average Years of Schooling		5.178 ***	5.644 ***	7.216 ***	5.829 ***	6.006 ***	5.310 ***
Time	0.034 ***	-0.023	-0.027 **	-0.045 **	-0.027	-0.030 *	-0.021
Current Exchange Rate	-0.969 ***	-1.106 ***	-1.143 ***	-1.168 ***	-1.174 ***	-1.159 ***	-1.169 ***
Lag GDP				-0.076		-0.048	
AIC	-116.5	-127.9	-126.7	-132.9	12.8*	15.5*	32.2*
BIC	-107.5	-118.8	-116.4	-120.4	20.7*	24.6*	52.7*

Note1: All variables in logarithm constant U.S. dollars.
Note2: Models selected by minimizing BIC and subject to non-rejection of Q- and LM-test.
Note3: Residuals in all the models pass the Q-test for white noise or LM test for autocorrelation.
Note4: Information criteria reported for IV and system estimation are calculated from estimated likelihood value and should not be compared with single equation
Note5: ***: significant at .01 level, **: at .05 level, and *: at .1 level.

Table 2

The estimation results of full system of equations are reported in Table 3. In addition to the output equation, the employment and capital stock equation are also estimated simultaneously. The model for employment and capital stock are selected by minimizing BIC subject to non-rejection of Q- and LM-test for residual autocorrelation. The maximum lag length considered are 4 lagged years for both equations. Residuals from each equation for all models are checked separately and the cannot be rejected as white noise by Q- and LM-test.

The first two columns in Table 2 report results from models with variables in growth rates. Column 3 and 4 report results from models with variables in

logarithm. With system estimation, the relations between outward investment and output, employment, and capital are simultaneous estimated. A negative relationship is found between lagged outward investment and current domestic employment. This negative relationship is commonly embraced in the literature. Interestingly, the lag is shorter for the effects of outward investment on employment. The time gap is only 1 year as compared to the two years time gap for the lagged effects of outward investment on GDP.

Despite the downward pressure outward investment impose on domestic labor services, intriguingly, the positive lagged effects of outward investment on GDP remain robust. The key coefficient hold its sign, magnitude, and significance levels across various model and model specification. Results consistently indicate the positive lagged effects of outward investment on output growth.

As discussed previously, other estimators in the GDP equation are also robust in their signs, magnitudes, and significance. Results however are less robust for the hypothesized negative relationship between outward and domestic investment. It is possible that, given that capital markets are relatively complete in the sense that capital flows accross activities and countries to arbitrage returns, an increase in investment opportunities, all else constant, induce an increase in foregone consumption, instead of substitution between domestic and outward investment.

Three-stage least squares regression				
Dependent variable: GDP	On Levels No Error Adjustment	On Levels No Error Adjustment	On Growth Rates AR(1) Error Adjustment	On Growth Rates AR(1) Error Adjustment
Current Capital Stock	-0.226		-0.044	
Lag1 Capital Stock		-0.026		0.017
Lag1 Domestic Investment		-0.076 **		-0.066 **
Lag1 Inward Investment		0.002		0.003
Lag2 Outward Investment	0.021 ***	0.023 ***	0.022 ***	0.020 ***
Current Employment	1.167 ***	1.131 ***	1.422 ***	1.027 ***
Schooling	5.310 ***	5.584 ***	3.244 **	5.025 ***
Time	-0.021	-0.036 **		
Exchange Rate	-1.169 ***	-1.014 ***	-1.015 ***	-1.086 ***
Intercept	-10.556 ***	-13.308 ***	-0.008	-0.025
Lag GDP		0.079		
Dependent Variable: Employment				
Lag1 Employment	0.641 ***	0.648 ***	0.379 **	0.445
Current GDP	0.134 ***	0.130 ***	0.155 ***	0.152 ***
Lag1 Outward Investment	-0.018 ***	-0.018 ***	-0.012 **	-0.010
Intercept	4.067 ***	3.983 ***	0.003	0.001
Dependent Variable: Capital Stock				
Lag1 Capital Stock	0.356 ***	0.376 ***	0.020	-0.022
Current GDP	0.290 *	0.205	-0.101	-0.388 ***
Lag1 Outward Investment	-0.013 *	-0.014 **	0.001	-0.003
Interest Rate for U.S. Treasury Bonds	0.022	0.023	0.009	0.024 **
Exchange Rate	-0.318	-0.429 **	-1.099 ***	-1.401 ***
Time	0.021 **	0.025 ***		
Intercept	5.187 ***	6.175 ***	0.049	0.037
AIC	32.23	35.89	31.46	34.62
BIC	52.66	59.74	53.04	58.47

Note1: All variables in constant U.S. dollars.
Note2: Selected models yield best information criteria in comparison.
Note3: Residuals in all the models pass the Q-test for white noise or LM test for autocorrelation.
Note4: Information criteria reported are calculated from estimated likelihood value and should not be compared with single equation v
Note5: ***: significant at .01 level, **: at .05 level, and *: at .1 level.

Table 3

6.2 Quarterly Results

Table 4 reports results from quarterly data estimation which undeniably confirm the story from the annual data analysis. Column 1 & 2 report the models that include lagged GDP in the output function and column 3 reports the model with time-varying seasonal dummies. Lagged dependent variable is introduced here to, first, reduce the autocorrelation in residuals and, second, to further test the stability of the focal coefficient. Despite the consistent negative effects of outward investment on domestic employment, the positive lagged effects of outward investment on domestic productive capacity remain robust in the data analyzed for the case of Taiwan. However, no linkage between outward investment and domestic investment is suggested by the quarterly results. Though of more nuisance in estimation, the quarterly results help to reinformce the results obtained from fitting the model to annual data.

Simultaneous Equation on Quarterly Growth Rates			
Dependent Variable: GDP	AR(1) for all Eqs	AR(1) for all Eqs	AR(4 8) for Eq1&3 and AR(1) for Eq2
Current Quarter Capital Stock	-1.032		-1.321
Lag 1 Quarter Capital Stock		0.337 **	
Lag 1 Quarter Domestic Investment		-0.033	
Lag 1 Quarter Invward Foreign Investment		0.004	
Lag 3 Quarter Outward Investment	0.012 **	0.012 **	0.012 **
Current Quarter Employment	0.498	0.569 *	0.936 **
Current Quarter Average Year of Schooling			-0.248
Current Quarter Exchange Rate	-0.889	0.282 **	-1.038
Quarter2 dummy	0.038 ***	0.026	
Quarter3 dummy	0.032 ***	0.031 ***	
Quarter4 dummy	0.021 **	0.015	
Year	0.000	-0.001 *	-0.001
Time-Varying Quarter 2 dummy			0.012
Time-Varying Quarter 3 dummy			0.036 **
Time-Varying Quarter 4 dummy			0.038 **
Time-Varying Quarter 2 dummy 1			0.120
Time-Varying Quarter 3 dummy 1			-0.088
Time-Varying Quarter 4 dummy 1			-0.090
Lag 1 Quarter GDP	0.345 *	0.368 **	
Dependent Variable: Employment			
Lag 1 Quarter Employment	0.165	0.171	0.111
Lag 4 Quarter Employment	0.339 ***	0.347 ***	0.346 ***
Lag 5 Quarter Employment	-0.285 **	-0.286 **	-0.244 **
Lag 7 Quarter Employment	-0.175 ***	-0.172 **	-0.181 ***
Lag 8 Quarter Employment	0.167 *	0.152	0.143
Current Quarter GDP	0.071 ***	0.065 **	0.065 **
Lag3 Quarter Outward Investment	-0.005 ***	-0.005 ***	-0.005 ***
Quarter3 dummy	0.006 **	0.007 **	0.007 ***
Dependent Variable: Capital Stock			
Lag 1 Quarter Capital Stock	-0.163	-0.134	0.510 ***
Lag 4 Quarter Capital Stock	-0.383 ***	-0.382 **	0.147
Lag 5 Quarter Capital Stock	0.080	0.083	-0.037
Current Quarter GDP	0.034	0.003	0.114 **
Rate of U.S. Treasury Bond	-0.043	-0.028	0.004
Quarter2 dummy	-0.011	-0.010	-0.015 ***
Quarter3 dummy	-0.016 **	-0.015 **	-0.015 ***
Quarter4 dummy	-0.015 **	-0.013 **	-0.011 **
Lag3 Quarter Outward Investment	0.000	0.000	-0.002
L-Hat	198.31	231.17	204.05
AIC	47.42	53.11	59.36
BIC	120.55	133.81	147.63

Note1: All vairables are in quarterly growth rates.
Note2: Residuals in all the models pass Q- or LM-test for autocorrelation.
Note3: Model reported are with best information cirterion.
Note4: Information criteria reported for IV and system estimation are calculated from estimated likelihood value and should not be compared with single equation values.
Note5: ***: significant at .01 level, **: at .05 level, and *: at .1 level.

Table 4

The positive indirect effects of outward investment on growth is net of the competing direct effects of outward investment on inputs. And the net positive effects stream from the dominance of productivity gain over labor service loss induced by outward investment. Only through the direct positive effects of outward investment on productivity advance can the positive effects of outward investment on GDP be sensible. The outward investment induced productivity gain can be channeled by elimination of inefficient firms, industry upgrading,

cost reduction efficiency of intermediate inputs, or other forces. Despite the channels, this outward investment induced productivity gain has to outweight the depressing pressure outward investment imposed on domestic labor demand for a positive "net" effects of outward investment to be observed. Future research interests therefore may further focus on the direct effects of outward investment on productivity advance in the home country.

7 Concluding Remarks and Future Study

Empirical investigation of Taiwanese output growth had found robust positive lagged effects of outward investment on GDP is found for the case of Taiwan. This positive causal relationship from outward investment to GDP prevails even after accounting for the downward pressure on employment imposed by outward investment. These findings contrast the general negative perception on economic performance and bear crucial relevance on economic policies. Although it is imprudent to reach policy conclusions that encourage outward investment, these findings do challenge the negative perceptions upon which conservative policies discouraging outward investment are based.

After successfully determining the positive relationship, the next important question is how these positive effects of outward investment on GDP are reached. The inability of time series framework to afford us the answers calls for future research efforts. Our ongoing research focus on structurally modeling the linkage between outward investment and production capacity in a dynamic general equilibrium framework. Structural analysis can better explain how the economic forces interact to accomplish the observed positive effects of outward investment on productive capacity. A structural framework also grants the ability of counter-factual analysis, which is otherwise impossible with econometric analysis.

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8 Appendix

8.1 Selected Graphs

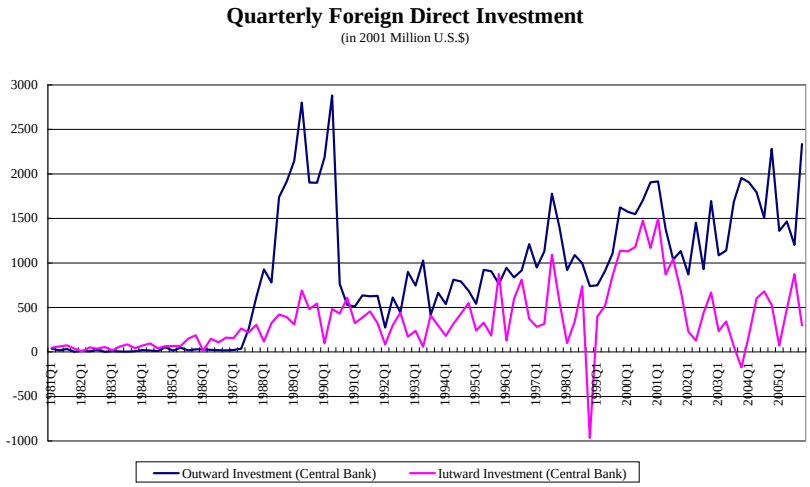

Figure A1

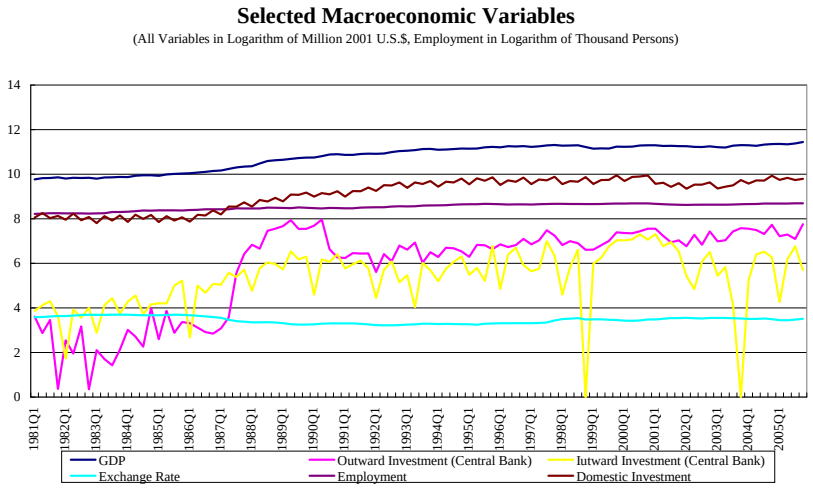

Figure A2

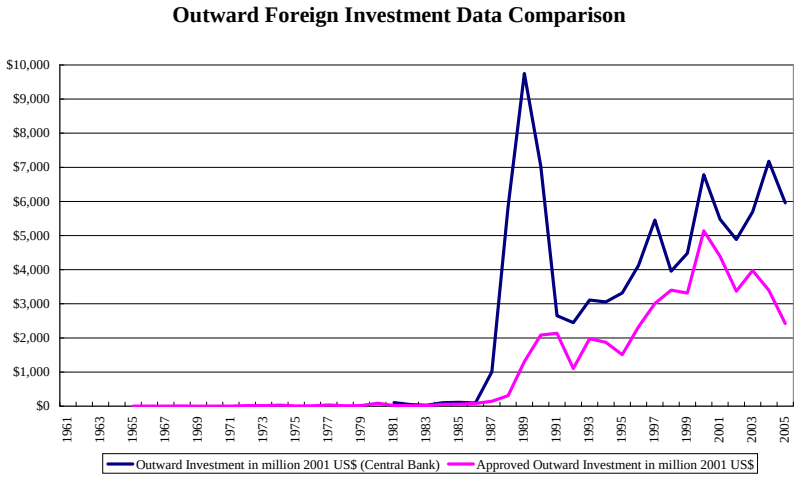

Figure A3

8.2 Estimated Models Derivation

As the literature established the distinct effects inward foreign investment on growth, it seems reasonable to decompose capital flow into two parts: domestic and inward foreign investment. Further, past studies had suggested the varieties effects of investment on capital, thus the effects of investment on capital stock are expected to be multiplicative rather than additive, $K_t = K_{t-1} \cdot D_{t-1}^{\mu_1} \cdot I_{t-1}^{\mu_2}$, where D_{t-1} is the domestic investment and I_{t-1} is the inward investment occurred during time period $t-1$, μ_1 and μ_2 are parameters. Let's assume the production function takes the form of a Cobb-Douglas production function. The output function can be expressed as:

$$Y_t = A_t K_t^{\alpha_1} (H_t L_t)^{\alpha_2} X_t^{1-\alpha_1-\alpha_2}$$

Let productivity and intermediate input function also take the form of: $A_t = \lambda_a \cdot O_{t-1}^{\upsilon_1} \cdot O_{t-2}^{\upsilon_2} \cdot e^{z \cdot t}$ and $X_t = \lambda_x \cdot {O_{t-1}}^{\varpi_1} \cdot {O_{t-2}}^{\varpi_2}$, where t stands for time, and $\lambda_a, \lambda_x, \upsilon_1, \upsilon_2, \varpi_1, \varpi_2$ and z are parameters. Although the theory suggests only the past values of investment to be included, it is unrealistic to believe, with annual data, that the investment occurred in a particular year do not contribute to the output in that year.[24] It seems reasonable to include current values of domestic and inward investment in the estimated model. Of course, the logics are different with quarterly data. The output function[25] can be written as[26]:

$$\begin{aligned} \ln Y_t &= \gamma_0 + \gamma_1 \ln K_{t-1} + \gamma_2 \ln D_t + \gamma_3 \ln I_t + \gamma_4 \ln D_{t-1} \\ &\quad + \gamma_5 \ln I_{t-1} + \gamma_6 \ln O_{t-1} + \gamma_7 \ln O_{t-2} \\ &\quad + \gamma_8 \ln L_t + \gamma_9 \ln S_t + \gamma_{10} t + \gamma_{11} \ln E_t + \epsilon_t \end{aligned}$$

where E_t is the exchange rate between Taiwanese and US dollars at year t and S_t is the average years of schooling for Taiwanese workforce measuring human capital, $\gamma_0 = \ln \lambda_x + \ln \lambda_a$, $\gamma_1 = \alpha_1$, $\gamma_2 = \alpha_1 \cdot \varsigma_D$, $\gamma_3 = \alpha_1 \cdot \varsigma_I$, $\gamma_4 = \alpha_1 \cdot \mu_D$, $\gamma_5 = \alpha_1 \cdot \mu_I$, $\gamma_6 = \alpha_1 \cdot (\nu_1 + (1-\alpha_1-\alpha_2)\varpi_1)$, and $\gamma_7 = \alpha_1 \cdot (\nu_2 + (1-\alpha_1-\alpha_2)\varpi_2)$.

Alternatively, the estimated model can be reduced to the following equation if the recovery of the effects of investments on GDP is not the primary research focus.

[24] The cross correlation showed the strongest relationship between GDP and both domestic and inward investment at the current year.

[25]

$$\begin{aligned} Y_t &= [\lambda_a \cdot O_{t-1}^{\upsilon_1} \cdot O_{t-2}^{\upsilon_2} \cdot e^{z \cdot t}] \cdot [K_{t-1} \cdot D_t^{\varsigma_D} \cdot I_t^{\varsigma_I} \cdot D_{t-1}^{\mu_D} \cdot I_{t-1}^{\mu_I}]^{\alpha_1} \\ &\quad \cdot H_t L_t^{\alpha_2} \cdot [\lambda_x \cdot O_{t-1}^{\varpi_1} \cdot O_{t-2}^{\varpi_2}]^{1-\alpha_1-\alpha_2} \end{aligned}$$

[26] Exchange rate is included for its usage to convert data on output, capital stock, and domestic investment into US dollars.

$$\begin{aligned}\ln Y_t &= \gamma_{0k} + \gamma_{1k}\ln K_t + \gamma_{6k}\ln O_{t-1} + \gamma_{7k}\ln O_{t-2} \\ &\quad +\gamma_{8k}\ln L_t + \gamma_{9k}\ln S_t + \gamma_{10k}t + \gamma_{11k}\ln E_t + \epsilon_t^k\end{aligned}$$

The hypotheses subject to statistic testing are: .

1. $\gamma_{6(k)} = 0$ or $\gamma_{7(k)} = 0$. At the aggregate level, the past levels of outward investment are not related to current values of output in the case of Taiwan.

   If the outward investment are to be separated into two types: defensive and expansionary outward investment, then the model can be estimated as:

$$\begin{aligned}\ln Y_t &= \eta_0 + \eta_1\ln K_{t-1} + \eta_2\ln D_t + \eta_3\ln I_t + \eta_4\ln D_{t-1} \\ &\quad +\eta_5\ln I_{t-1} + \eta_6\ln EO_{t-1} + \eta_7\ln EO_{t-2} \\ &\quad +\eta_8\ln DO_{t-1} + \eta_9\ln DO_{t-2} + \eta_{10}\cdot t + \eta_{11}E_t + \epsilon_t^1\end{aligned}$$

2. $\eta_6 > 0$ or $\eta_7 > 0$ or $\eta_8 < 0$ or $\eta_9 < 0$. If the perceptions of expansionary and defensive outward investment are true, the effects of past expansionary outward investment on output are expected to be positive and the effects of past defensive outward investment on output are expected to be negative.[27]

8.2.1 Model Estimation with Quarterly Data

The derivation of the quarterly model is very similar to the annual one. The model estimated for the quarterly data is:

$$\begin{aligned}\ln Y_t &= \iota_0 + \iota_1\ln K_t + \iota_4\ln O_{t-3} + \iota_7\ln L_t \\ &\quad +\iota_8\ln S + \iota_9\ln E_t + \boldsymbol{\iota}_{10}\cdot\mathbf{q} + \iota_{11}\cdot t + \epsilon_t^q\end{aligned}$$

Alternatively, $\iota_1\ln K_t$

where q is a vector of dummy variables capturing deterministic or time-varying deterministic seasonality.

$$\begin{aligned}q &= \{q_2, q_3, q_4\} \text{ or} \\ &\quad \left\{\begin{array}{c} q_2(G(t;c_1,c_2)), q_3(G(t;c_1,c_2)) \\ , q_4(G(t;c_1,c_2)), q_2(1-G(t;c_1,c_2)) \\ , q_3(1-G(t;c_1,c_2)), q_4(1-G(t;c_1,c_2)) \end{array}\right\}\end{aligned}$$

q_i is the dummy variable represents the i^{th} quarter of the year and $G(t;c_1,c_2) = \frac{1}{1+\exp\{-c_1(t-c_2)\}}$.

[27] Alternatively, the output function can also be estimated in sectoral levels to uncover the possibly different story at the levels of a less aggregate economy. The measure adopted to separate industries into slow- and fast-growing sectors is already stated in previous section.

8.3 Addidtional Results for Sensitivity Check

Table A1. Annaul results of estimated output function in growth rates

Dependent Variable: Growth Rates in GDP in Million 2001 U.S. Dollars					
Variables	IV Estimation: Employment Instrumented	IV Estimation: Capital Stock Instrumented	Simultaneous Equation Estimation		Simultaneous Estimation (NTD)
Current Capital Stock		-0.2719	-0.044		-0.112
Lag Capital Stock	0.034			0.017	
Lag Domestic Capital Formation	-0.061 *			-0.066 **	
Lag Inward Foreign Investments	0.001			0.003	
Lag 2 period Outward Foreign Investments	0.017 ***	0.017 ***	0.022 ***	0.020 ***	0.018 ***
Current Employment	0.983 ***	0.944 ***	1.422 ***	1.027 ***	1.044 ***
Average Years of Schooling	3.914 ***	3.121 *	3.244 **	5.025 ***	3.824 ***
Current Exchange Rate	-1.103 ***	-1.310 ***	-1.015 ***	-1.086 ***	
AIC	18.2*	11.1*	31.5*	34.6*	26.8*
BIC	31.8*	17.9*	53.0*	58.5*	46.1*

Note1: All variables in growth rates in constant U.S. dollars.
Note2: Selected models yield best information criteria.
Note3: Residuals in all the models pass the Q-test for white noise or LM test for autocorrelation.
Note4: Information criteria reported are calculated from estimated likelihood value and should not be compared with single equation values.
Note5: ***: significant at .01 level and **: at .05 level.

Table A1

Table A2 Annual results of estimated output function in N.T. dollars

Dependent Variable: GDP in constant million N.T. Dollars.						
	Single Equation Estimation				System Estimation	
	Levels		Growth Rates		Growth Rates	Levels
Current Capital Stock		-0.196 **		-0.112	-0.110	-0.058
Lag Capital Stock	0.130		-0.017			
Current Domestic Capital Formation	0.054					
Lag Domestic Capital Formation	-0.074 ***		-0.050			
Current Inward Foreign Investments	0.000					
Lag Inward Foreign Investments	0.006		0.002			
Lag Outward Foreign Investments	0.003	-0.010	0.001	-0.005		
Lag 2 period Outward Foreign Investments	0.023 ***	0.020 ***	0.021	0.020 **	0.018 ***	0.021 ***
Current Employment	1.074 ***	0.814 ***	1.112 ***	0.998 ***	1.037 ***	1.072 ***
Average Years of Schooling	5.025 ***	4.228 ***	4.243 ***	3.228 ***	4.015 ***	4.858 ***
Time	-0.035	-0.019				-0.022
Current Exchange Rate	-0.017					
Lag GDP		0.299 **				
AIC/ Estimated Likelihood Value	-135.68	-131.48	-111.72	-112.33	36.18*	28.91*
BIC	-120.92	-121.26	-101.90	-104.70		

Note1: All variables in constant NT dollars.
Note2: Models selected by minimizing BIC and subject to no rejection of Q- and LM-test.
Note3: Residuals in all the models pass the Q-test for white noise or LM test for autocorrelation.
Note4: Information criteria reported for IV and system estimation are calculated from estimated likelihood value and should not be compared with single equation values.
Note5: ***: significant at .01 level, **: at .05 level, *: at .1 level.

Table A2