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# Foreign Direct Investment and Economic Growth in Taiwan's Manufacturing Industries

Vei-Lin Chan

## 12.1 Introduction

In endogenous growth theory, which explains growth by endogenizing technological change, foreign direct investment (FDI) and international trade are considered to be major channels for transmitting ideas and new technologies. This paper analyzes the Taiwanese experience regarding these potential factors of growth. Its primary purpose is to evaluate the role of FDI in explaining economic growth in Taiwan and to ascertain whether movements in FDI help to predict movements in economic growth. The effects of other pertinent factors, such as fixed investment and volume of exports are also analyzed.

The features of this study are the following. The first concerns the data set. Most empirical studies in endogenous growth use cross-country macro-aggregate data; as such, they seldom consider differences across industries within a country. This paper uses more disaggregated manufacturing industry panel data, which are formed by pooling all time-series and cross-sectional data at the two-digit industry level. As far as I know, this data set has not been used before in the growth literature about Taiwan.

The second feature has to do with methodology. This paper conducts a number of Granger causality tests regarding manufacturing sector data. The main hypothesis concerns whether FDI "Granger causes" economic growth. This is more informative than merely ascertaining a positive asso-

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ciation between, say, FDI and economic growth. We can find similar discussions of the role of fixed capital formation or trade in economic growth using cross-country data in King and Levine (1994), Carroll and Weil (1994), Blomström, Lipsey, and Zejan (1996) and Frankel and Romer (1999).[1]

Our test results support a causal relation from FDI to economic growth. Furthermore, we would like to ascertain the channel through which FDI affects growth. Two kinds of channels are possible from pure theoretical reasoning. First, FDI could induce technology transfer, thus causing an advance in technology, which in turn promotes economic growth in the host country. Or, second, FDI may induce fixed investment or exports and thus affect economic growth through increased aggregate demand. Now, which of these two possible channels reflects the Taiwanese situation?

A brief review of the relevant literature is in order. Based on growth accounting, earlier empirical studies overwhelmingly supported the view that factor accumulation plays a dominant role in the extraordinary performance of East Asian countries (see, e.g., Kim and Lau 1994; Young 1995; Collins and Bosworth 1996). This view is now under debate due to the findings of Klenow and Rodríguez-Clare (1997), Rodrik (1997), and Hsieh (1999), which have stated that technological progress accounts for a significant portion of workers' productivity growth in East Asia.

A number of studies have investigated the role of FDI in growth. Findlay (1978) and Wang (1990) suggested that FDI would promote economic growth through its effect on technology adoption (see Kozumi and Kopecky 1980; Wang and Blomström 1992; Malley and Moutos 1994). Markusen and Venables (1997) showed that FDI is complementary to local industry and would stimulate development in host economies through several channels. Their analytical work was consistent with the case study by Hobday (1995), which included industries in Taiwan. Recently, a cross-country regression by Borensztein, De Gregorio, and Lee (1998) has supported the view that FDI affects economic growth through technology diffusion.

Among studies on Taiwan, Ranis and Schive (1985) examined the role of FDI in Taiwan's development from 1952 to 1980 by industrial case study. They found that FDI played an important role in Taiwan's early economic development and thus confirmed that FDI is an efficient channel of technology transfer from overseas to Taiwan. Using 1986 and 1991 survey data for Taiwan, Chen, Hsu, and Chen (1999) found that FDI has no or even has negative effects on labor productivity when examining the competing channels of technology adoption. Thus it seems that the role

1. In fact, some of them find that the positive association between fixed capital formation and economic growth is mainly due to the effect of economic growth on fixed capital formation instead of a causal relation from fixed capital formation to economic growth.

of FDI in Taiwan's economic development needs further clarification through time-series data.

As regards the role of domestic investment, an interesting question concerns whether FDI crowds out or crowds in domestic investment. Due to competition for physical and financial resources or competition in the product market, one may view subsidiaries and multinational corporations (MNCs) and domestic investment as substitutes. On the other hand, on account of the linkage effects due to a cheaper intermediary good produced by subsidiaries and MNCs, or the spillover effects of foreign capital that would stimulate domestic investment, foreign investment and domestic investment could also be complements. The overall effect may go either way. Tu (1989) found a crowding-in effect in the overall economy, but a crowding-out effect in Taiwanese manufacturing industries. Similarly, FDI and exports can be complements or substitutes. International trade signifies the movement of commodities, and FDI signifies the movement of capital. From this point of view, international trade and FDI are substitutes. But if the object of FDI is to cut costs of exports by utilizing cheaper labor in export-oriented industries, exports and FDI are complementary. Hence, which relation is true is an empirical question.

Now we can state the second part of our results. We find causal relations from fixed investment and exports to economic growth. But the hypotheses that FDI affects economic growth by inducing more investment and exports are not supported by our test results. This seems to indicate that FDI affects growth through technological progress.

The remainder of the paper is organized as follows. Section 12.2 provides an overall picture of Taiwan's growth experience and specific data on the manufacturing sector and FDI. Section 12.3 states the model and discusses the data. Section 12.4 summarizes the empirical results. Section 12.5 concludes the paper.

## 12.2 Some Background Material about Taiwan

### 12.2.1 General Background

Taiwan has experienced rather high growth rates in the past four decades (see, e.g., Tsiang 1984). In the 1950s, the agricultural sector accounted for 30 percent of total GDP, and the main exports were agricultural or processed agricultural products, which accounted for 80 percent of total exports. The share of agricultural sector GDP in total GDP declined rapidly. It was for example, 7.7 percent in 1980 and a mere 3 percent in 1997. The Taiwanese economy took off in the mid-1960s. With a two-digit average GDP growth rate in the manufacturing sector, Taiwan gradually transformed itself into a newly industrialized economy. The manufacturing sector has become the largest single sector in Taiwan's economy.

But recently its share in GDP declined a little due to the rapid growth of the service sector.[2]

Because of the active export-promoting policy, the values of exports and imports are quite high relative to GDP in Taiwan. This reflects the "processing nature" of Taiwan's industries. Moreover, since the mid-1960s there has been an active policy of encouraging FDI by giving tax credits and setting up export-processing zones. FDI was concentrated in labor-intensive industries in the 1960s, and in more diversified and sophisticated industries afterward.

### 12.2.2 Manufacturing Sector

This paper will focus on the manufacturing sector, which has been the leading sector in Taiwan's economy. Table 12.1 shows the contribution of the manufacturing sector and two-digit industries to growth. On average, the manufacturing sector grew faster than the overall economy before the 1980s, but slower than the overall economy in the 1990s, due to the rapid expansion of the service sector. Manufacturing's percentage contribution to the total GDP growth rate rose from 30 percent (3.02 out of 9.79 percent) in the 1960s to around 40 percent in the 1970s and the 1980s (4.20 out of 10.23 percent and 3.11 out of 8.15 percent, respectively). In the 1990s, manufacturing contributed 20 percent (1.28 out of 6.32 percent) of the GDP growth rate. The manufacturing sector accounted for 3 to 4 percentage points of the total GDP growth rate before the 1980s and barely 1.3 percentage points after the 1980s. The change reflects the trend of industrial restructuring in Taiwan since the late 1980s.

It is also interesting to note the shift in the role of capital-intensive versus labor-intensive two-digit industries in the manufacturing sector. While a capital-intensive industry such as electronics (ELE) contributed 47 percent (1.89 out of 4.03 percent) of the manufacturing GDP growth rate in the 1990s, the contributions of traditional industries (such as TEX, APPAREL, LEATHER, WOOD, and PAPER) to manufacturing became negative. Note that before 1990, the percentage contribution of electronics to manufacturing was no more than 15 percent. This shift partly reflects the fact that these labor-intensive industries moved their production to Southeast Asia and China. These moves may have to do with the rapid appreciation of the New Taiwan dollar and rising production costs since the 1980s. (See table 12.1 for details.)

2. Taiwan has experienced industrial restructuring since the late 1980s. GDP of the service sector (which includes commerce, transport, storage and communications, government services, finance, insurance, business services, and personal services) as a percentage of total GDP has risen dramatically from a steady 46 percent over 1952–86 to 63.1 percent in 1998. In the meantime, GDP of the manufacturing sector as a percentage of total GDP has fallen from a peak of 39.4 percent in 1986 to 27.0 percent in 1998.

**Table 12.1 Contribution to Economic Growth Rate of Manufacturing Sector, 1962–96 (percent)**

| Industry | 1962–96 | 1962–69 | 1970–79 | 1980–89 | 1990–96 |
|---|---|---|---|---|---|
| GDP growth rate | 8.75 | 9.79 | 10.23 | 8.15 | 6.32 |
| Manufacturing GDP growth rate | 11.03 | 16.15 | 14.34 | 8.51 | 4.03 |
| Contribution of manufacturing GDP to total GDP growth rate | 3.04 | 3.02 | 4.20 | 3.11 | 1.28 |
| Contribution of two-digit industry GDP to manufacturing GDP growth rate[a] | | | | | |
| FOOD | 1.36 | 3.52 | 1.18 | 0.61 | 0.24 |
| TEX | 0.96 | 1.69 | 1.48 | 0.57 | −0.08 |
| APPAREL | 0.46 | 0.49 | 0.97 | 0.37 | −0.20 |
| LEATHER | 0.11 | 0.03 | 0.28 | 0.13 | −0.09 |
| WOOD | 0.30 | 0.62 | 0.51 | 0.17 | −0.16 |
| PAPER | 0.39 | 0.47 | 0.65 | 0.39 | −0.08 |
| CHEM | 1.64 | 2.23 | 1.92 | 1.51 | 0.74 |
| Petroleum[b] | 1.08 | 2.05 | 0.79 | 0.90 | 0.65 |
| NMP | 0.44 | 0.68 | 0.53 | 0.32 | 0.19 |
| FMP | 1.02 | 0.52 | 1.59 | 1.00 | 0.81 |
| MEQ | 0.42 | 0.52 | 0.48 | 0.38 | 0.26 |
| ELE | 1.66 | 1.79 | 1.83 | 1.24 | 1.89 |
| TRAN | 0.69 | 1.06 | 0.79 | 0.67 | 0.14 |
| INS | 0.51 | 0.47 | 1.34 | 0.26 | −0.28 |

*Source: National Income, Taiwan Area, the Republic of China.*

[a]For two-digit industry abbreviations, see appendix.

[b]Petroleum and coal products.

### 12.2.3 Foreign Direct Investment

FDI had at least a two-digit average growth rate in every decade. Growth in FDI slowed a bit in the 1970s and 1990s. The average share of FDI going to the manufacturing sector peaked in the 1970s; and even though this average share then lost 30 percentage points within the next two decades, the manufacturing sector still receives most FDI in the 1990s. This decline in average share is due to a shift in FDI from the manufacturing sector to the banking, insurance, and service sectors in the past decade. (See table 12.2 for details.)

Japan and the United States are two major sources of foreign capital; investment from these two countries together accounts for at least half of FDI in Taiwan. They are also the world's most important source countries of capital outflow. In general, the United States provides more capital in the PAPER, CHEM, and ELE industries, and Japan provides more capital in the remaining manufacturing industries and in the service sector. (See table 12.3 for more details.)

The overall ratio of FDI to fixed investment was not so high and has

**Table 12.2** **Industry Distribution of FDI by Decade, 1953–97**

| Industry | 1953–97 | 1953–59 | 1960–69 | 1970–79 | 1980–89 | 1990–97 |
|---|---|---|---|---|---|---|
| Growth rate of total FDI (%) | 293.28 | 346.58 | 1,022.78 | 15.61 | 33.12 | 13.69 |
| Growth rate of FDI into manufacturing (%) | 456.98 | 667.95 | 1,538.00 | 21.11 | 32.39 | 23.05 |
| Share of manufacturing FDI in total FDI (%) | 79.16 | 77.11 | 86.68 | 90.23 | 76.92 | 60.51 |
| Share of two-digit industries FDI in manufacturing FDI[a] (%) | | | | | | |
| FOOD (1954) | 8.79 | 33.06 | 4.78 | 0.61 | 5.57 | 6.80 |
| TEX (1953) | 3.79 | 14.29 | 2.02 | 2.55 | 0.92 | 1.94 |
| APPAREL (1961) | 0.82 | 0.00 | 1.74 | 0.77 | 0.46 | 0.89 |
| LEATHER (1961) | 0.25 | 0.00 | 0.24 | 0.17 | 0.12 | 0.73 |
| WOOD (1963) | 0.30 | 0.00 | 0.17 | 0.40 | 0.29 | 0.63 |
| PAPER (1966) | 0.38 | 0.00 | 0.37 | 0.33 | 0.74 | 0.34 |
| CHEM (1954) | 28.77 | 38.03 | 41.87 | 17.88 | 26.85 | 20.30 |
| NMP (1961) | 1.71 | 0.00 | 0.89 | 2.46 | 2.65 | 2.12 |
| FMP (1961) | 7.74 | 0.00 | 5.58 | 10.11 | 10.85 | 10.36 |
| MEQ (1954) | 8.10 | 0.35 | 2.53 | 12.74 | 15.07 | 7.34 |
| ELE (1958) | 38.26 | 14.29 | 39.81 | 51.99 | 36.49 | 42.37 |
| TRAN (1993) | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 4.97 |
| INS (1993) | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 1.21 |

*Source: Statistics on Overseas Chinese and Foreign Investment, Technical Cooperation, Outward Investment, Outward Technical Cooperation, and Indirect Mainland Investment, the Republic of China.*

[a]Values in parentheses are years that data start to be nonzero.

**Table 12.3** **Sources of FDI, 1952–97 (percent)**

| | Asia | | | North America | | | |
|---|---|---|---|---|---|---|---|
| Industry | Hong Kong | Japan | Other | United States | Other | Europe | Other |
| Total | 7.66 | 28.40 | 5.53 | 26.48 | 12.82 | 12.93 | 6.18 |
| Banking, insurance, trade, and services | 11.65 | 29.26 | 7.26 | 18.95 | 12.77 | 15.69 | 4.44 |
| Manufacturing | 6.32 | 28.64 | 3.50 | 31.30 | 8.40 | 14.89 | 6.95 |
| FOOD | 8.99 | 22.95 | 5.51 | 19.66 | 14.26 | 10.50 | 18.12 |
| TEX | 6.40 | 34.75 | 12.87 | 7.46 | 24.50 | 11.28 | 2.74 |
| APPAREL | 10.75 | 49.01 | 4.81 | 3.63 | 28.32 | 3.37 | 0.10 |
| LEATHER | 3.20 | 5.04 | 0.00 | 3.18 | 80.62 | 4.95 | 3.01 |
| WOOD | 31.34 | 37.89 | 5.06 | 2.29 | 13.22 | 10.20 | 0.00 |
| PAPER | 11.68 | 14.00 | 0.00 | 55.17 | 12.56 | 2.02 | 4.57 |
| CHEM | 6.20 | 22.43 | 0.97 | 32.88 | 5.34 | 25.57 | 6.61 |
| NMP | 19.82 | 36.95 | 4.06 | 12.66 | 4.31 | 21.45 | 0.74 |
| FMP | 5.24 | 30.91 | 1.32 | 14.43 | 7.96 | 6.18 | 33.95 |
| MEQ | 5.62 | 47.85 | 1.54 | 17.92 | 15.18 | 8.22 | 3.67 |
| ELE | 4.53 | 28.81 | 6.51 | 43.67 | 7.55 | 8.68 | 0.24 |
| TRAN | 20.06 | 56.14 | 2.28 | 7.11 | 8.71 | 5.66 | 0.04 |
| INS | 6.67 | 39.07 | 17.47 | 5.47 | 23.87 | 7.46 | 0.00 |

*Source:* See table 12.1 source.

Table 12.4 **FDI as a Percentage of Gross Investment by Two-Digit Manufacturing Industry, 1961–96**

| Industry | 1961–96 | 1961–69 | 1970–79 | 1980–89 | 1990–96 |
|---|---|---|---|---|---|
| Manufacturing | 13.22 | 17.15 | 13.57 | 12.21 | 9.08 |
| FOOD | 5.49 | 2.58 | 0.60 | 10.06 | 9.66 |
| TEX | 1.76 | 0.94 | 2.13 | 1.22 | 3.07 |
| APPAREL | 8.81 | 15.37 | 4.34 | 4.88 | 12.37 |
| LEATHER | 59.48 | 201.71 | 23.20 | 1.90 | 10.71 |
| WOOD | 2.55 | 1.35 | 2.21 | 2.08 | 5.25 |
| PAPER | 1.36 | 2.32 | 0.69 | 1.72 | 0.56 |
| CHEM | 18.65 | 35.11 | 11.55 | 16.32 | 10.98 |
| NMP | 6.59 | 2.94 | 9.54 | 8.14 | 4.85 |
| FMP | 15.98 | 16.24 | 31.61 | 8.20 | 4.43 |
| MEQ | 45.77 | 23.85 | 64.36 | 63.68 | 21.82 |
| ELE | 76.20 | 160.42 | 78.07 | 36.71 | 21.68 |
| TRAN | 1.21 | 0.00 | 0.00 | 0.00 | 6.20 |
| INS | 0.85 | 0.00 | 0.00 | 0.00 | 4.35 |

*Source:* See table 12.2 source.

declined. It was no more than 20 percent in the 1960s and only about 9 percent for the manufacturing sector in the 1990s.[3] FDI is not a major source of capital for most manufacturing industries. Domestic investment is much more important for manufacturing industries. Among them, CHEM, MEO, and ELE have higher ratios of FDI to fixed investment than other industries across different decades. (See table 12.4.)

## 12.3 Model and Data

### 12.3.1 Model

We perform the Granger causality test on the pooled time-series and cross-sectional data of two-digit manufacturing industries. The bivariate variable model is given by

$$(1)\quad Z_{it} = \alpha_0 + \sum_{j=1}^{p} \alpha_j \cdot Z_{i,t-j} + \sum_{j=1}^{p} \beta_j \cdot X_{i,t-j} + f_i + \lambda_t + \varepsilon_{it},$$

where $i$ and $t$ denote industries and years, respectively. The dependent variable is $Z$. The explanatory variables include the lagged dependent variable and the variable $X$. We consider the specification of industry and time fixed effects: $f_i$ is the industry fixed effect and $\lambda_t$ is the time fixed effect.

3. Since FDI is computed on an approval basis, not on an actual arrival basis, it is possible that the ratio of FDI to fixed investment exceeds 100 percent for particular industries in particular periods (e.g., as shown in table 12.4, the ratio was 160 percent for ELE in the 1960s).

The term $\varepsilon_{it}$ is a disturbance. The Granger causality test is used to determine whether the addition of the lagged variable $X$ (i.e., $p$ restrictions on the coefficients of the lagged variable $X$) is statistically significant using both $F$-tests and Wald ($\chi^2$) tests. The theoretical model does not provide guidance on the appropriate lag length $p$. For the panel data, we arbitrarily choose lag length $p$ to be two and four.

Note that the results may be sensitive to the model specifications. To test for Granger causality from variable $X$ to variable $Z$, the multivariate model for panel data is estimated and given by

$$(2)\quad Z_{it} = \alpha_0 + \sum_{j=1}^{p}\alpha_j \cdot Z_{i,t-j} + \sum_{j=1}^{p}\beta_j \cdot X_{i,t-j} + \sum_{m=i}^{n}\sum_{j=1}^{p}\gamma_j \cdot Y_{j,m,t-j} + f_i + \lambda_t + \varepsilon_{it}.$$

Explanatory variables include the lagged dependent variable $Z$, the variable $X$, and the variables $Y_m$, $m = 1, \ldots, n$, which are the relevant variables. Among the variables $Y_m$, $H_t$ is the human capital stock proxy, assumed to be common to all two-digit industries.

Equations (1) and (2) are estimated using OLS. The OLS estimates of equations (1) and (2) are biased in the presence of industry fixed effects and the lagged dependent variable. But Nickell (1981) has shown that the bias is inversely related to the number of sample periods. Our sample period spans twenty-three years, so the bias in the estimate is likely to be small. We thus can ignore this problem.

We first perform the Granger causality test from FDI to growth in real GDP. We also perform the Granger causality test from fixed capital formation and exports, respectively, to economic growth. To avoid bias due to excessive zero values, we consider eleven two-digit industries only when the model includes FDI.

In a multivariate model, various combinations of human capital, fixed investment, exports, and FDI would alternatively be used as explanatory variables in equation (2). The human capital proxy and fixed investment have been shown to positively affect economic growth in numerous empirical endogenous growth studies. Moreover, traditional trade theory argues that export expansion affects economic growth positively by increasing resource allocation efficiency and capacity utilization. Recent studies have emphasized the role of exports as a channel for promoting technical change. Most empirical results support a positive and significant effect of export expansion on economic growth.[4] The causality result should be carefully explored due to some econometric problems. One is the possibility that trade is endogenous, which would cause a simultaneity problem. Frankel and Romer (1999) have dealt with this problem by using a geographical factor and have still supported the hypothesis that trade raises

4. See Harrison (1996) for a survey of relevant empirical studies.

income using cross-country regression. Their method is not applicable to the present situation in which we deal with only one country. And the issue of simultaneity is not treated in this paper. The analysis focuses on testing whether FDI "Granger causes" economic growth while controlling for human capital, fixed capital formation, and exports at the two-digit industry level in Taiwan's manufacturing sector.

We further investigate whether FDI affects economic growth by increasing fixed investment and exports. We perform Granger causality tests from FDI to fixed investment and exports, respectively. The presence of a growth effect of FDI and the absence of positive causal relation from FDI to fixed investment and exports suggest that FDI promotes economic growth through technological improvement instead of accumulation of capital and increase in exports.

### 12.3.2 Data

The econometric analysis will use the following variables: for each industry, GGDP is growth in real GDP, FDIY is the ratio of approved investment by foreign nationals to GDP, INVY is the ratio of fixed capital formation to its own GDP, EXPY is the ratio of exports to GDP, and JH and SH are proxies for the human capital stock. Table 12.5 reports summary statistics on GGDP, FDIY, INVY, EXPY, and TEXPY for the manufacturing sector and two-digit manufacturing industries. TEXPY is the ratio of exports for the individual two-digit manufacturing industry to total exports in the manufacturing sector. It provides information on trade share for an individual industry relative to other manufacturing industries.

Over our sample period, 1973–94, traditional industries such as FOOD, TEX, APPAREL, and WOOD had lower average GDP growth rates while newly developed industries such as FMP and ELE had higher two-digit average GDP growth rates. FDIY is much lower than INVY for every industry, as shown in table 12.5. MEQ, ELE, and CHEM had much higher average FDIY than other industries. MEQ was the only industry with FDIY that was more than half of its INVY.

The industries ELE, CHEM, APPAREL, and INS, which had the highest average TEXPY, were the major export manufacturing industries. They accounted for about 59 percent of exports in manufacturing. However, in terms of the ratio to industry's own GDP, INS, LEATHER, ELE, and APPAREL had high average export shares EXPY. The fact that EXPY is higher than 100 percent percentage points for many industries may appear odd at the first glance, but it just reflects the general "processing nature" of Taiwan's industries.

## 12.4 Empirical Results

Table 12.6 reports the results of causality tests for the panel data. *P*-values for *F*-tests (*upper numbers*) and Wald tests (*lower numbers*) of the

Table 12.5 **Summary Statistics of Variables in Manufacturing Industries, 1978–94 (percent)**

| Industry | GGDP | | FDIY | | INVY | | TEXPY | | EXPY | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| Manufacturing | 8.3 | 7.0 | 1.8 | 0.8 | 18.2 | 4.4 | 100.0 | – | 122.5 | 11.3 |
| FOOD | 5.6 | 8.0 | 1.0 | 1.0 | 11.1 | 1.7 | 6.1 | 2.6 | 57.8 | 13.2 |
| TEX | 5.6 | 13.5 | 0.4 | 0.4 | 24.0 | 17.2 | 8.9 | 2.0 | 125.9 | 24.0 |
| APPAREL | 4.0 | 14.1 | 0.3 | 0.3 | 4.3 | 2.1 | 12.2 | 4.0 | 90.16 | 64.5 |
| LEATHER | 11.1 | 18.3 | 1.0 | 1.0 | 7.8 | 2.3 | 2.4 | 0.7 | 217.7 | 70.6 |
| WOOD | 5.0 | 18.9 | 0.3 | 0.3 | 12.3 | 3.5 | 4.9 | 2.3 | 191.1 | 71.6 |
| PAPER | 7.2 | 11.2 | 0.3 | 0.3 | 20.8 | 6.9 | 0.8 | 0.2 | 22.9 | 6.5 |
| CHEM | 10.0 | 9.5 | 1.8 | 1.8 | 25.7 | 7.7 | 12.6 | 1.4 | 104.1 | 17.1 |
| NMP | 9.6 | 9.1 | 4.0 | 4.0 | 20.3 | 6.8 | 1.8 | 0.4 | 53.9 | 19.4 |
| FMP | 13.2 | 18.3 | 0.9 | 0.9 | 31.5 | 20.6 | 7.5 | 1.8 | 91.0 | 16.3 |
| MEQ | 9.9 | 8.9 | 9.1 | 9.1 | 14.9 | 3.9 | 5.0 | 1.7 | 166.3 | 22.4 |
| ELE | 11.7 | 15.9 | 3.1 | 3.1 | 16.0 | 2.5 | 22.1 | 5.0 | 207.7 | 33.7 |
| TRAN | 10.0 | 12.7 | – | – | 16.2 | 11.2 | 4.1 | 1.1 | 78.6 | 16.5 |
| INS | 8.1 | 20.1 | – | – | 7.6 | 1.9 | 11.8 | 2.0 | 240.0 | 36.6 |

*Source:* See table 12.2 source.

**Table 12.6** **Granger Causality Tests for Annual Panel Data**

| | Model | | | | |
|---|---|---|---|---|---|
| Relation and Lag | I | II | III | IV | V |
| FDIY→GGDP[a] | | | | | |
| $p = 2$ | 0.23 | 0.14 | 0.15 | 0.08 | 0.08 |
| | 0.17 | 0.03 | 0.03 | 0.04 | 0.05 |
| $p = 4$ | 0.52 | 0.80 | 0.46 | 0.63 | 0.25 |
| | 0.41 | 0.01 | 0.01 | 0.01 | 0.14 |
| INVY→GGDP[b] | | | | | |
| $p = 2$ | 0.23 | 0.23 | 0.23 | 0.20 | 0.20 |
| | 0.28 | 0.18 | 0.32 | 0.15 | 0.08 |
| $p = 4$ | 0.03 | 0.72 | 0.03 | 0.61 | 0.01 |
| | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| EXPY→GGDP[c] | | | | | |
| $p = 2$ | 0.02 | 0.02 | 0.02 | 0.02 | |
| | 0.01 | 0.01 | 0.01 | 0.00 | |
| $p = 4$ | 0.05 | 0.03 | 0.66 | 0.03 | |
| | 0.01 | 0.01 | 0.00 | 0.01 | |
| FDIY→INVY[d] | | | | | |
| $p = 2$ | 0.05 | 0.07 | 0.06 | | |
| | 0.03 | 0.04 | 0.59 | | |
| $p = 4$ | 0.32 | 0.33 | 0.38 | | |
| | 0.22 | 0.21 | 0.51 | | |
| FDIY→EXPY[e] | | | | | |
| $p = 2$ | 0.16 | 0.17 | 0.13 | | |
| | 0.11 | 0.12 | 0.85 | | |
| $p = 4$ | 0.97 | 0.96 | 0.91 | | |
| | 0.95 | 0.94 | 0.47 | | |

[a]Model I is a two-variable model that includes GGDP and FDIY. Models II and III are four-variable models that include GGDP, FDIY, INVY, and JH and GGDP, FDIY, INVY, and SH, respectively. Models IV and V are five-variable models that add EXPY to Models II and III, respectively.

[b]Model I is a two-variable model that includes GGDP and INVY. Models II and III are three-variable models that include GGDP, INVY, and JH and GGDP, INVY, and SH, respectively. Models IV and V are four-variable models that add EXPY to Models II and III, respectively.

[c]Model I is a two-variable model that includes GGDP and EXPY. Model II is a three-variable model that includes GGDP, EXPY, and INVY. Models III and IV are four-variable models that add JH and SH to Model II, respectively.

[d]Model I is a two-variable model that includes FDIY and INVY. Model II is a three-variable model that includes FDIY, INVY, and GGDP. Model III is a four-variable model that includes FDIY, INVY, GGDP, and EXPY.

[e]Model I is a two-variable model that includes FDIY and EXPY. Model II is a three-variable model that includes FDIY, EXPY, and GGDP. Model III is a four-variable model that includes FDIY, EXPY, GGDP, and INVY.

Granger causality tests are based on a least squares with dummy variables estimation. Model I is a bivariate model. The others are multivariate models as described in notes to the table.

Regarding the Granger causality test from FDIY to GGDP, the test results are somewhat sensitive to the choices of model specification, lag length, and test statistic. In all cases, the $p$-values of the $F$-statistics are larger than those of the $\chi_2$ statistics in the respective GGDP equations. The addition of explanatory variables somewhat lowers both sets of $p$-values. Most $\chi_2$ test statistics reject the null hypothesis that all of the coefficients on lagged FDIY are zero. The significant estimated coefficients are all positive. The results support a causal relation from FDIY to GGDP in a multivariate model.

In the Granger causality test from INVY to GGDP, most test statistics for the case $p = 4$ reject the null hypothesis that all of the coefficients on lagged INVY are zero. The evidence indicates that the coefficients on later lags are likely to be nonzero. Thus it takes a long time for fixed capital formation to affect economic growth.

For the Granger causality test from EXPY to GGDP, all but one test statistic suggest that EXPY Granger-causes GGDP. The results are quite robust with respect to the choices of model specification, lag length, and test statistic. The evidence hence strongly supports a predictive role for export share. These results are consistent with findings of earlier empirical studies that indicate that exports promote economic growth in developing countries.

In summary, at the two-digit industry level in Taiwan's manufacturing sector, Granger causality tests suggest causal relations from FDI, fixed investment, and exports to economic growth. The result that fixed investment plays a major role in promoting economic growth in the manufacturing sector supports capital fundamentalism. The significant causal relations from FDI and exports to economic growth also support the belief that total factor productivity matters in the process of economic growth.

We further investigate whether the presence of a positive causal relation from FDIY to GGDP is through capital accumulation or through exports. Most test statistics support the causal relation from FDIY to INVY when $p = 2$. This causal relation disappears for a longer period (i.e., $p = 4$). We therefore conclude that FDI does not Granger-cause fixed investment. Also, note that most estimated coefficients of FDIY are negative. They imply that the substitution effect dominates the complementary effect. Our finding of a crowding-out effect in Taiwanese manufacturing is consistent with those of Tu (1989). Finally, none of the statistics support a causal relation from FDIY to EXPY. Both sets of results indicate that FDI does not promote economic growth by increasing total capital accumulation or exports. The channel of technology improvement is the key to the growth effect of FDI.

## 12.5 Conclusion

The source of economic growth has long been a central issue in economics. Recently, endogenous growth theory has provided a new direction from which to study the determinants of economic growth. And FDI is one of the channels emphasized by R&D-based endogenous growth theory. This paper investigates the causal relation from FDI to GDP growth in the Taiwanese manufacturing sector while controlling human capital, fixed capital formation, and exports at the two-digit industry level. The results based on comprehensive panel data of two-digit industries support in general a causal relation from FDI. Furthermore, our results do not find a positive causal relation from FDI to fixed investment and exports. This indicates that FDI promotes economic growth, not by increasing total capital accumulation or exports, but, more likely, through the channel of technology improvement. This would be quite consistent with R&D-based endogenous growth theory.

Therefore, this paper represents a step forward in clarifying the role of FDI as a source of economic growth in Taiwan. The evidence, as it stands, for technological advancement as the channel through which FDI affects growth is still rather indirect. Future research is needed to provide more direct evidence on this matter. For example, one could assess, using Taiwanese macrodata, the effects of FDI on technology advancement and of technology on growth.

Currently, the Taiwanese government aims to promote Taiwan as an Asian-Pacific Regional Operations Center (APROC). One objective of the APROC project is to overcome bureaucratic inertia on reform, which has been a major impediment to the efficacy of Taiwan's government. Another objective is to promote economic relations between Taiwan and Southeast Asia. It will be interesting to see how the APROC project can attract FDI to Taiwan and can stimulate the advancement of operational technology in Taiwan.

# Appendix

## *Data Sources*

For each individual two-digit manufacturing industry, GGDP is growth in real GDP, and INVY is the ratio of fixed capital formation to its own GDP. Data are from *National Income, Taiwan Area, the Republic of China.* EXPY is the ratio of exports to GDP. Export data come from *Monthly Statistics of Exports and Imports, Taiwan Area, the Republic of China.* To explain economic growth, recent empirical studies on endogenous growth have emphasized educational attainment measures as human capital proxies to augment the labor input measure in the production function. We use primary and secondary school enrollment rates, JH and SH, respectively, as proxies for the human capital stock. Data are from *Monthly Bulletin of Manpower Statistics, Taiwan Area, the Republic of China.*

FDI in the manufacturing sector has been overwhelmingly dominated by foreign nationals. Also, in channeling funds into Taiwan's economy, overseas Chinese investment has been intended to provide scarce capital rather than to transfer technology. The early restrictions on investment in service industries by foreign nationals are another reason. Therefore, FDI used in the analysis refers to investment made by foreign nationals only. FDIY is the ratio of approved investment by foreign nationals to GDP. Statistics on approved FDI are from *Statistics on Overseas Chinese and Foreign Investment, Outward Investment, Technical Cooperation, Outward Technical Cooperation, Indirect Mainland Investment, Guide of Mainland Industry Technology, Investment Commission, Ministry of Economic Affairs, the Republic of China.*

The manufacturing sector is disaggregated into thirteen industries: foods, beverages, and tobacco (FOOD); textiles (TEX); wearing apparel and accessories (APPAREL); leather and fur products (LEATHER); wood and bamboo (WOOD); paper, paper products, and printing processing products (PAPER); rubber, plastic, and chemical products (CHEM); nonmetallic mineral products (NMP); basic metal products and fabricated metal products (FMP); machinery and equipment (MEQ); electric and electronic machinery (ELE); transportation equipment (TRAN); and precision instruments and miscellaneous manufacturing (INS).

According to Taiwan's 1991 official industrial classification for manufacturing, there are twenty two-digit industries. One issue concerns the Chinese Petroleum Corporation, a public corporation in the petroleum and coal product industry, which has enjoyed a monopolistic position. We hence exclude petroleum and coal products from our data set. To match the classifications of two-digit manufacturing industries for international trade, FDI, and real GDP data as closely as possible, several two-digit industries are pooled due to the availability of data.[5] The sample period of this compatible data set is 1972–94. Approved FDI for TRAN and INS have nonzero values only in 1995 and 1996. Thus these two industries will be also excluded from our econometric analysis.

5. The classification of two-digit manufacturing sectors for export and import data is based on the *Standard Classification of Commodities of the Republic of China (C.C.C.).* This commodity classification has changed several times. To match the classification for import and export data to that of real GDP data, we choose the classification that has only eighteen two-digit industries in manufacturing and covers the period from January 1972 to June 1995. The number of manufacturing subsectors for FDI is thirteen because data for basic metals and metal products are pooled. So the sample period is 1972–94 and the number of subsectors in manufacturing is thirteen. Four subgroups are subject to the availability of export and import data: (1) rubber and plastic products; (2) wood, bamboo, and rattan products; (3) paper allied products and printed matter; and (4) beverage and tobacco products.

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## **Comment** Mari Pangestu

This paper examines the basic relations between trade, fixed investment, FDI, and economic growth for the case of Taiwan and confined to the manufacturing sector. Chan uses a rich data set and utilizes the standard Granger causality test to prove causality among these variables. The author concludes that there is a causal relation from FDI to economic growth through technology improvement rather than through increasing total capital accumulation or exports.

The lack of role for FDI with regard to exports is surprising given that in the early years of Taiwan's export promotion strategy, FDI was actively encouraged through various export promotion policies and incentives. Further explanation is needed as to why FDI's role with regard to exports was not found to be significant. It could be that FDI was important to export growth in the earlier period, when the main motivation was employing low-cost labor and using Taiwan as an export base, and much less so afterward, due to the changing nature of FDI going to Taiwan. It could also be due to the nature of the relation between FDI and domestic companies in subcontracting and owner equipment manufacturing relationships. Furthermore, it is entirely possible that technological advancement through FDI had an important impact on competitiveness and productivity, and therefore on exports and growth.

Similarly, FDI was also not important for capital accumulation, and here an explanation of what *has* been important for capital accumulation would be useful, such as the roles of domestic savings and investment.

It is also not clear why the tests undertaken for exports and fixed investment were not also applied to human capital, as the link between FDI and human capital is potentially important.

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The interesting result with regard to the role of FDI in technological advancement and thus indirectly growth needs to be further explored because of its important policy implications. Chan does point out that the evidence as it stands provides only indirect evidence with regard to the effect of technological advancement through FDI on growth. In addition to analyzing further the relation between the effects of FDI on technological advancement and of technology on growth using macrodata, it would be worthwhile to look at the nature of the interaction of technological advancement through FDI with exports, productivity, and competitiveness. Such quantitative results could also be supplemented by a discussion of case studies of particular sectors, industries, and companies or subsets of companies.

Another area of future research would be to analyze possible sectoral differences in whether FDI affects economic growth through increasing exports or fixed investment. For instance, FDI is expected to play a role in increasing exports for export-oriented sectors such as garments and electronics.

The policy implications are also important and need to be drawn out more. The promotion of Taiwan as a regional headquarters may attract the types of FDI that can contribute to technological advancement. However, other policies need to be identified and discussed further. For instance, are there particular sectors or even companies that should be targeted to contribute to technological advancement in Taiwan? If so, then active sector- or incentive-specific approaches may be needed, much like those undertaken by the Economic Development Board in Singapore. More general policies can maximize the impact of technological advancement on growth, such as policies that maximize the potential for domestic linkages and spillovers, education policy, and incentives for R&D.

## Comment Masatsugu Tsuji

The purpose of this paper is to estimate the effects of domestic investment, trade, and FDI on economic growth in Taiwan's manufacturing sector. Chan selects thirteen major industries in the manufacturing sector and analyzes them with panel data. The paper thus provides a comprehensive study. Using time-series data, the author fully applies the Granger causality test. The analysis follows such fundamental procedures in time-series analysis as the unit root test, the cointegration test, and the error correction model. The conclusion is that FDI in the electric and electronic ma-

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chinery industry (ELE), currently one of the country's major industries, is the most influential factor in Taiwan's economic growth. It is of interest to see how each individual industry affects the economy differently.

I have been engaging in research on the growth and industrial transformation of the machine tool industry in East Asian economies such as Japan, Korea, Taiwan, and China. Although my method of research is entirely different, I have learned much from this paper. My approach is based on microdata obtained by field research. I visited factories, job shops, and company headquarters and interviewed workers on assembly lines, R&D researchers, managers, and top management. According to Chan's classification, the machine tool industry is part of the machinery and equipment industry (MEQ). According to table 12.2, the amount of FDI in MEQ as a percentage of total manufacturing investment ranks third following ELE and CHEM during the sample period. There is, however, an interesting contrast between ELE and MEQ. ELE affects the growth of real GDP (GGDP), but MEQ does not. On the other hand, domestic investment in MEQ affects GGDP, but that in ELE does not. The author does not interpret the results in detail. From my field research, I can interpret this difference between the two industries as follows: Japanese machine tool builders are highly reluctant to transfer technology to other countries. They are afraid of a "boomerang effect," so they supply core devices, or "black boxes." Thus the Japanese machine tool industry is one of the least globalized. When we refer to FDI, we must recognize many differences in characteristics such as nationality, industry, and the management of individual firms. Since macrodata erase those differences, care should be taken when interpreting the conclusions of the paper.

The following are comments on the technical aspects of the estimation: First, the Granger causality test does not indicate a quantitative relation among variables but rather a qualitative one. The estimated results may not reveal a quantitative relationship; they show only that there is some relation of investment, trade, and FDI with GGDP. In order to estimate quantitative influence, the author must conduct a supplementary analysis, such as estimating the impulse reaction function. If such an analysis were integrated into the paper, it would have more extensive results. It may also be advisable to directly estimate the usual structural equations and compare the coefficients of the variables. This method seems to be rather simple but meets the purpose of the author's research.

Another interesting point is found in the methodology—for example, the application of the Granger causality test to panel data. The following question naturally arises: Why does Chan adhere to the fixed-effects model a priori? Usually in panel data analysis, the fixed-effects model and the random-effects model, for instance, are tested using the Hausman test. The suitable model is then selected according to the results of that test.