Human Capital, Trade, FDI and Economic Growth in Thailand: What causes What?

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Abstract

We investigate the causal links between human capital, openness through trade and FDI, and economic growth using quarterly data for Thailand over the period 1973:2-2000:4. A number of hypotheses are investigated including, in particular, FDI-led growth and export-led growth, as well as the reverse linkages from growth to FDI and exports. The importance of human capital is highlighted as complementary to trade and FDI inflows, underlying the importance of technology adoption. We find that, after controlling for domestic investment, government expenditure and imports, support for FDI-led growth is not as strong as export-led growth, although allowing for the joint interaction of FDI and human capital reveals a positive FDI effect above a minimum threshold of human capital, estimated to be around 4.5 years of average secondary schooling attainment. Extending our study using multivariate causality tests conducted within a vector error correction framework, we also find significant effects of domestic investment and trade openness, providing support for import-led growth, but direct support for FDI-led growth as well as growth-led FDI is again relatively weak, reinforcing the conclusion that trade openness has played a more significant role than FDI in influencing Thai economic growth. But the results reveal a subtle role for technology transfer through the complementary effect of trade on FDI, and FDI on government expenditure, which thereby influences human capital development with spillovers onto domestic investment and growth. This leads us to argue that there is a potential role for FDI interacting with human capital in influencing the future development of the Thai economy, given its recently active policy of FDI promotion.

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1. Introduction

The issue of foreign direct investment interacting with economic growth in developing countries has become increasingly important because many developing countries have adopted a more liberal policy towards FDI since the mid-1980s in order to accelerate their economic growth. Relevant literature on this issue might be divided into two groups. The first is based on growth theory in which FDI is introduced as one of the factors explaining output growth, stressing the importance of knowledge spillovers or technology transfer in addition to capital formation (Das (1987); Din (1994); Rodriguez-Clare (1996), Balasubramanyam, Salisu and Sapsford (1996), Borensztein, De Gregorio and Lee (1998)). Technology transfer occurs when the advanced technologies embodied in FDI are transferred to domestic plants through the presence of multinational firms. According to new growth theory, such spillover affects host economies through changes in the nature of market concentration as well as through transfer of technological, managerial and financial practices in the industries that the multinational firm enters. Further, for developing countries to benefit from spillover they need to nurture their absorptive capacity, which depends on the human capital or skill content of their workforce (Nelson and Phelp (1966), Lall (1992)). These considerations lead to the hypothesis of FDI-led growth.

The second group of studies focuses on the importance of factors explaining the existence of multinational firms, which suggests that FDI is attracted to host countries because of the possibilities of higher returns. Viewed as a substitute for domestic capital, FDI inflows increase with higher domestic demand for capital generated by economic growth in host countries. Expanding domestic markets also make it possible for multinational firms to exploit economies of scale [Markusen (1995)]. Moreover, improvements in human capital development, labour productivity and infrastructure through economic growth would increase the marginal return to capital, thereby expanding the demand for investment including FDI [Zhang and Markusen (1999)]. In short, better economic performance in host countries provides foreign investors with a better investment environment and greater opportunities for making profits, suggesting the hypothesis of growth-driven FDI.

Many empirical studies have tested these hypotheses: this paper draws its flesh mainly from the important study by Borensztein et al. (1998) who carry out a cross-section empirical analysis to examine the effect of FDI on economic growth. Their results suggest that FDI is an important vehicle for the transfer of technology, contributing relatively more to output growth than domestic investment. However, the higher productivity of FDI holds only when the host country has a minimum threshold stock of human capital. Thus, they argue that FDI contributes to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host economy. We investigate this issue for Thailand, whether that FDI-led growth is critically dependent on a minimum threshold level of human capital (educational attainment).

More generally, we seek to establish the causal link between FDI and economic growth, which might suggest important implications for development strategies for Thailand. Causality from FDI to productivity growth would lend credence to the FDI-led growth hypothesis. If the causal process were in the reverse direction, this would imply that economic growth is a prerequisite for Thailand to attract FDI. In either case, the impact of FDI flows will also depend on the country's absorptive capacity. If the causal process is bi-directional, then FDI and growth are interdependent, and thereby a virtuous cycle could be expected.

However, in testing the above hypotheses we also investigate the relationship between openness (allowing for trade versus FDI) and economic growth for Thailand, and focus more specifically on the comparison between FDI-led growth and export-led growth. Our methodological framework for causality testing is a multivariate VAR model in which other relevant factors (e.g. domestic investment, human capital, exports, imports, etc.) are allowed to exert their influence apart from the two basic variables (FDI or FDI * H and per capita GDP growth). This permits us to investigate the importance of other factors on the growth of the Thai economy, allowing also to test the export-led growth hypothesis for Thailand: whether higher external trade has led to higher economic growth and what role imports has played in this regard.

Our main finding from the causality tests is that support for FDI-led growth is not as strong as export-led growth for Thailand. We also find that economic growth in Thailand has influenced domestic investment growth and trade expansion, but support for growth-led FDI is also weak. This finding is robust with respect to a variety of VAR specifications entertained, and allowing for the effect of human capital and its interaction with FDI does not make much difference to the results. To investigate the magnitude of the causal influences and to distinguish between short run and long run effects, we go a step further by estimating an error correction model using quarterly data for Thailand over the period 1973:2-2004:4. Once again, we find that the effect of trade on Thai productivity growth is significant, while that of FDI *per se* is not, although the joint interaction of FDI and human capital reveals in this case a positive FDI effect above a minimum threshold level of human capital, estimated to be about 4.5 years of secondary schooling attainment. This finding is not robust, although we stress the importance of Thailand policy towards education and the accumulation of human capital for future growth potential.

2. The empirical model

A model for testing the above hypotheses can be derived from a standard neoclassical production function in which *FDI* is introduced as an input in addition to labour and domestic capital (De Mello (1997)). New growth theory emphasises the importance of investment in physical and human capital for economic growth and increasing returns to both types of capital (Lucas (1988), Romer (1986), Mankiw et al. (1992)). However, as Balasubramanyam et al (1996) argue, many of the growth promoting factors identified by new growth theory can be imitated and nurtured to promote growth through FDI, provided the economic climate and the nature of the trade policy regime is such that supports the creation of human capital, increasing returns to scale and spillover effects, identified by new growth theory as essential ingredients for economic growth. In this context, international trade or trade liberalisation could be another important channel for promoting growth, as it increases the size of the market and allows the country to use a large variety of technologically advanced physical capital, which enhances the productivity of its own resources (Grossman and Helpman (1991)). These considerations would suggest the inclusion of both trade components and FDI as arguments in the production function, besides labour and domestic capital.

Another possibility, advanced by endogenous growth theory, is that growth-enhancing technological progress results from deliberate innovation, facilitated in an environment of imperfect competition (Romer (1990), Aghion and Howitt (1992), Grossman and Helpman (1992)). Developed economies benefit from more resources allocated to R&D, and access to the technological capabilities of these countries can by acquired, or imitated, by developing countries through international trade and FDI. However, Borensztein et al (1998) argue that the application of such advanced technologies requires the presence of a sufficient level of human capital in the host economy, and they highlight the roles of both the introduction of more advanced technology and the requirement of a sufficient absorptive capability in the host country as determinants of economic growth. Empirically, they investigate the complementarity between FDI and human capital on economic growth by estimating the effects of both FDI and FDI*H in their specification.

To investigate the relative importance of these influences, Borensztein et al. (1998) develop a growth model in which technical progress, a determinant of growth, is represented through the variety of capital goods available. Technical progress is itself determined by *FDI* as foreign firms encourage adoption of new technologies and increase the production of capital goods, hence increasing variety. Thus, *FDI* leads to growth via technology transfer that increases total factor productivity. Certain host country conditions are necessary to ensure the positive spillover effects. In particular, a critical level of human capital (an educated labour force) is necessary for new technology and management skills to be absorbed. They derive, in a cross country context, the following basic estimating equation, where *g* is growth in real *GDP*, *FDI* is the ratio of *FDI* to *GDP, H* is a measure of schooling and Y_0 is initial GDP:

$$g = c_0 + c_1 FDI + c_2 FDI * H + c_3 H + c_4 Y_0 \qquad (1)$$

where, across most specifications they estimate using panel data for 69 developing countries over two periods, 1970-1979 and 1980-1989, they find that the coefficient on the interaction term (*FDI*H*) is positive and consistently significant but that of *FDI* is not (often negative when significant). They interpret their finding as implying that *FDI* has a positive impact on growth but this is only realised when *H* is above some critical level (estimated as 0.52); at lower levels of *H*, *FDI* therefore has a negative or insignificant effect on growth.

Recent developments in endogenous growth literature also suggest that long run growth can result from more open and liberal government policies conducive to the inflow of foreign capital (Barro (1991), Barro and Xala-I-Martin (1995)). Allowing separately for the influence of human capital (*H*), domestic investment (*I*) and trade components (*EX* and *IM*), our time-series specification for *GDP* per capita (*gpc*) is a dynamic version of the following regression:

$$gpc_t = \beta_1 + \beta_2 H_t + \beta_3 I_t + \beta_4 FDI_t + \beta_5 FDI * H_t + \beta_6 GX_t + \beta_7 EX_t + \beta_8 IM_t + \varepsilon_t \tag{2}$$

where we regard *H*, *I* and *GX* as the conditioning variables for testing the effect of openness through trade and *FDI*.[1] Our specification can be considered as a straight forward extension of the specification (1) in order to test for the influence of technology transfer through trade openness or FDI, thus allowing, at minimum, the inclusion of the additional terms *EX* and *IM*[2]. In a time-series context, given the possibility of cointegration among the aggregate variables, the appropriate empirical formulation is of the error-correction type:

$$\Delta \ln gpc_t = \beta_1 + \beta_2 \Delta \ln H_t + \beta_3 \Delta \ln I_t + \beta_4 \Delta \ln FDI_t + \beta_5 \Delta \ln FDI * H_t + \beta_6 \Delta \ln GX_t + \beta_7 \Delta \ln EX_t + \beta_8 \Delta \ln IM + EC_{t-1} + \varepsilon_t \tag{3}$$

where

$$EC_t = \ln gpc_t - \hat{\gamma}_1 \ln H_t - \hat{\gamma}_2 \ln I_t - \hat{\gamma}_3 \ln FDI_t - \hat{\gamma}_4 \ln(FDI * H)_t - \hat{\gamma}_5 \ln GX_t - \hat{\gamma}_6 \ln EX_t - \hat{\gamma}_7 \ln IM_t \tag{4}$$

and *Δ* is the difference operator to reflect the growth rates of the (log-transformed) variables.

In the error-correction form we can effectively determine the separate influences of the short-run (equation 3) and the long-run (the steady-state formulation in equation 4) on per capita growth. The coefficient of *H* (β_2) is expected to be positive, in the simplest term this means that an increase in the number of attainment students in the secondary school of education will result in an increase in GDP growth. The coefficient of *I* (β_3) is expected to be positive as it is generally accepted

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[1] The addition of conditioning variables to control for other influences is common in cross-country studies, see e.g. Barro (1991). Borensztein et al. (1998) allow for the causal influence of *FDI*H* on per capita GDP growth to be conditioned by the inclusion of government expenditure, in order to isolate the effect of technology transfer through policy related inflences such as domestic innovation.

[2] Because we apply a time series model, the initial level of GDP per capita Y_0 is ignored as in (1), this being only relevant in a cross-country context. Our empirical results also include the effect of trade openness by combining the separate influences of *EX* and *IM* in the variable *OPEN=EX+IM*, expressed as proportion of *GDP*.

that investment is a key variable determining economic growth, and thus when evaluating the impact of FDI on economic development in a host country a key question arises whether foreign investment crowds in domestic investment or whether it has the opposite effects of displacing domestic producers. This means that the sign coefficient of *FDI* ($\beta 4$) can be positive or negative depending on whether the increase in foreign capital stock complements or substitutes for domestic investment, where as the coefficient of *FDI*H* (β_5) is should have a positive sign because a higher level of human capital is often associated with a greater transfer of technology which is growth enhancing. Government consumption is expected to be negative because collective consumption goods such as housing and salaries of public employees may directly or indirectly (via output taxes and subsidies) crowd out private consumption expenditures and thus affect output in a negative fashion (Aschauer (1990) and Sala-i-Martin (1995)). However, it may also be the case that part of these expenditures goes to financing primary and secondary education (as they do in several developed and developing countries, including Thailand). To the extent that they do, they may in the long run transmit a positive spillover effect in to domestic investment in the form of a better educated workforce that can efficiently seize the market opportunities offered by the transfer of technology and managerial know-how with *FDI*, thus affecting output in a positive manner to support a positive sign in coefficient *FDI*H* (β_5) above. The coefficient of *EX* (β_7) is expected to have a positive sign because increased exports, as proxy for a higher degree of openness is often associated with a greater technology transfer, learning by doing, greater market discipline, and an additional outlet for the goods and services produced by domestic firms (Tyler 1981; Feder 1983; Ram 1987; Moschos 1989). The inclusion of imports explicitly in the specification allows for control of imports in the investigation of export-led or FDI-led growth effects. Apart from theory which suggests that imports may play a control role in explaining export-led growth, omitting imports from the analysis may overstate the effects of exports or *FDI* on growth (as we find below, see also Riezman et al. (1996)). The coefficient of *IM* (β_8) can, however, be either negative or positive depending on the composition of imports. If imports are mainly capital goods, this may have a positive long run effect on growth mainly through domestic investment.

3. Methodology

3.1. Causality Testing in a VAR model

Many tests of causality have been derived and implemented, including Granger (1969), Sims (1972) and Geweke et al. (1982) (see Hamilton (1994)). Although it is quite straightforward to test for the direction of causality between two given variables, the conclusions drawn are delicate for two main reasons. Firstly, the choice of the lag length in the autoregressive distributed lag or VAR model will critically affect the outcome. Secondly, if there is cointegration among the sets of variables, spurious causality may be identified if an unrestricted VAR is employed. We attempt to overcome these shortcomings by following the now standard three-stage procedure: (i) unit root testing, taking account of the lag lengths using the Akaike criterion (AIC) (ii) checking for cointegration among the variables using the Johansen maximum likelihood ratio tests (Johansen (1991)), and (iii) estimating the appropriate VAR model, restricted or unrestricted, depending on whether the variables are cointegrated or not.

Consider the unrestricted VAR,

$$z_t = c + A_1 z_{t-1} + \ldots + A_k z_{t-k} + \varepsilon_t \qquad \varepsilon_t \sim IN(0,\Sigma) \tag{5}$$

where z_t is $(n \times 1)$ vector and each of the A_i is an $(n \times n)$ matrix of parameters. To illustrate a procedure for testing causality, we need to represent this system for one subset of z variables conditional on the other. Thus, consider $z_t = (y_t\,,\, x_t)'$, then (5) can be written as

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} A_{11}^1 & A_{12}^1 \\ A_{21}^1 & A_{22}^1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} A_{11}^k & A_{12}^k \\ A_{21}^k & A_{22}^k \end{bmatrix} \begin{bmatrix} y_{t-k} \\ x_{t-k} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{6}$$

where y_t is $(n_1 \; x \; 1)$ and x_t is $(n_2 \times 1)$ where $n_1 + n_2 = n$, and A_{ij}^h are the sub-matrices of parameters associated to the VAR, with superscripts denoting the order of the lags of the VAR, $h = 1,\ldots,k$ and c_1 and c_2 are vectors of constants. In this representation, the absence of causality from past values of x to y corresponds to the elements of the sub-matrices $A_{12}^h = 0$ for $h = 1,\ldots k$.

In a bivariate case, where y_t and x_t are individual variables, we can represent the two variable VAR system by the following equations:

$$y_t = c_1 + \sum_{i=1}^{k} a_{11}^{i} y_{t-i} + \sum_{j=1}^{k} a_{12}^{j} x_{t-j} + \varepsilon_{1t} \tag{7a}$$

$$x_t = c_2 + \sum_{i=1}^{k} a_{21}^{i} x_{t-i} + \sum_{j=1}^{k} a_{22}^{j} y_{t-j} + \varepsilon_{2t} \tag{7b}$$

In this case, Granger causality from *x* and *y* implies that a_{12}^{j} coefficients are jointly significant. More precisely, *x* does not Granger-cause *y* if the hypotheses H_0: $a_{12}^{j} = 0$ is not rejected. Conversely, *y* does not Granger-cause *x* if the hypothesis H_0: $a_{22}^{j} = 0$ is not rejected.

The standard practice, particularly in the bivariate case, is to use the F-statistic for testing the joint significant of the null hypothesis. An alternative, particularly useful when investigating causality within a multivariate VAR or VECM framework, is to use the X^2 (Wald) test statistic (Toda and Phillips (1993)).

3.2 Causality Testing in Vector Error Correction Models

As argued by Granger (1988), standard Granger-causality tests are invalid if the time series are nonstationary. Further, if cointegration is established, then a vector ECM, or cointegrated VAR, should be used to investigate causality. The advantage of VECM as opposed to the unrestricted VAR is that the information in about the long run is retained in the cointegrating combinations, and the stationarity properties of the variables involved in the system are properly taken into consideration (Johansen (1991); Johansen and Katarina (1992)).

The VAR model (5) can be reformulated alternatively in the (VECM) form:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + u_t \tag{8}$$

where $\Gamma_i = -(I - A_i - ... - A_i), (i = 1,...,k-1)$, and $\Pi = -(I - A_1 - ... - A_k)$. This way of specifying the system contains information on both the short run and long run adjustment to changes in z_t, via the estimates of Γ_i and Π respectively. If z_t is I(1), then Δz_t is I(0), but stationarity of the system must also depend on Πz_{t-k} to be I(0). This implies that there must exist up to $(n - 1)$ cointegrating relationships for the system to be stationary. Assuming that there are $r \le (n - 1)$ cointegrating vectors in the system, then Π can be factorised as $\Pi = \alpha\beta'$, where α and β are $(n \times r)$ matrices, the elements of α represents the speeds of adjustment (or feedback parameters in the error correction form) and β being a matrix of long run coefficients such that the term $\beta' z_{t-k}$ represents the cointegrating relationships in the system (i.e. r columns of β form r linearly independent combinations of the variables in z_t, each of which is stationary) to ensure that $\beta' z_{t-k} \sim$ I(0).

Furthermore, for the system (8) to be stationary, the remaining $(n - r)$ columns of β (comprising the I(1) common trends) would not be represented in the system, implying that the last $(n - r)$ columns of α are insignificantly small (or effectively zero), so that Πz_{t-k} is also I(0) in (8), and z_t will converge to its long run steady state solution. Thus, determining how many $r \le (n - 1)$ cointegration vectors exist in β amounts to equivalently testing which columns of the matrix α is zero. Consequently, testing for cointegration amounts to checking the rank of Π, that is, finding the number of r linearly independent columns in Π. Actual tests of cointegration (namely the trace and the maximum eigenvalue tests) amount to determining the rank of Π. Johansen (1991) derives these tests and estimates of α and β by maximum likelihood using a procedure known as reduced rank regression.

Now, in a bivariate system, let $z_t = [y_t, x_t]'$, and for ease of exposition suppose $k = 2$, then the system with $\Pi = \alpha\beta'$ can be written as:

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} \\ \beta_{12} & \beta_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} \quad (9)$$

The absence of cointegration in the above system means that in principle the elements of α matrix are all zero. With one cointegrating vector (r=1) we expect the second column of the α matrix to be zero (i.e. $\alpha_{12} = \alpha_{22} = 0$). In this case, α_{11} represents the speed of adjustment at which Δy_t adjusts towards the single long run cointegration relationship ($\beta_{11} y_{t-1} + \beta_{21} x_{t-1}$), while α_{21} represents the speed at which Δx_t responds to the disequilibrium changes represented by the cointegration vector. However, if $\alpha_{21} = \alpha_{22} = 0$ (i.e. zero second row of the α matrix), then the equation for Δx_t contains no information about the long run β since the cointegration relationships do not enter into this equation, and it is therefore valid to condition on the weakly exogenous variable x_t and proceed with the following conditional VECM model:

$$\Delta y_t = \tilde{\phi}_0 \Delta x_t + \tilde{\phi}_1 \Delta z_{t-1} + \tilde{\alpha}\beta' z_{t-1} + \tilde{u}_t \qquad (10)$$

where $\tilde{\alpha}$ is equal to α with $\alpha_{21} = \alpha_{22} = 0$[3]. Note, the weakly exogenous variable, x_t, remains in the long-run model (i.e., the cointegration vectors) although its short run behaviour is not modelled because of the exclusion from the vector on the left hand side of the equation. Thus, weak exogeneity of a variable in the VECM can be tested by checking for the presence of all zeros in the appropriate row of the α matrix.

Causality inferences among pairs of variables in the multivariate VECM model are based upon estimating the parameters of the model, subject to the predetermined number of cointegrating vectors in the system, using the Johansen maximum likelihood method. Then, absence of causality *in the short run* implies that the lagged coefficient values of the first difference terms of the relevant causal variable in the VECM are jointly insignificant. However, Toda and Phillips (1993) show that non-causality in VECM also involves, in addition, some nonlinear restrictions, comprising elements of α and β matrices. To illustrate, non-causality from x to y in the bivariate system (9) implies not only $\phi_{12} = 0$ but also $\alpha_{11}\beta_{11} + \alpha_{12}\beta_{22} = 0$. Hall and Milne (1994) introduce the notion of the absence of weak causality to denote the situation in which the long run level of one or more variables is unaffected by the levels of others. In (9), this is testable via zero restrictions on the appropriate row of the α matrix, which is equivalent to weak exogeneity. Following Hall and Milne, it is noted that if weak non-causality is rejected, then Granger non-causality, which in addition involves the remaining higher-order short run dynamics, also is rejected. Thus, estimating the

[3] The parameterisation in (10) is somewhat altered form the unconditional VAR, as it is assumed that the latter is decomposed into a conditional model for y_t given x_t, and a marginal model for x_t (not shown). Note, (10) is an error-correction representation that assumes weak exogeneity of x_t.

full VECM model, and testing restrictions on the appropriate long run and short-run adjustment coefficients allows investigation of bi-directional causality between two variables. The test procedure is therefore sequential to the establishment of weak non-causality from the cointegrating vector to the dependent variable, or equivalently weak exogeneity in the VECM model, as a sufficient condition.[4]

In sum, if all series are I(1) but cointegrated, we use a vector error correction model (VECM) to test for non-causality among the variables of interest, since cointegration implies the existence of a long-run constraint that needs to be accounted for. In the absence of cointegration, we use the stationary (first differenced) VAR representation, since this takes into account the implicit constraint that there is no cointegration. (Toda and Phillips (1993)).

4. Data Analysis and Empirical Results

The empirical results reported in this section are based on data collected for the following variables: GDP per capita (*GDPPC*), domestic investment (*I*), human capital (*H*), government expenditure (*GX*), exports (*EX*), imports (*IM*), Foreign Direct Investment (*FDI).* Additionally, we construct a measure of trade openness (*OPEN =(EX+IM)/GDP*) as a substitute for exports and imports. In the spirit of sensitivity analysis, variants of the VAR model comprising subsets or combinations of these variables are entertained with varying lag lengths to check for the robustness of the results.

4.1 Data

The data set used is quarterly and covers the period 1973:2-2000:4. All data except that for human capital are extracted from International Financial Statistics published by IMF, and deflated at 1995 prices. For human capital we have used the index on educational attainment for Thailand from Barro and Lee (1993, 2000), converted into quarterly by linear interpolation. This measures the average number of schooling years attended by population, both male and female, aged 25+.

[4] Simultaneous testing of the joint restrictions is not possible, as the asymptotic distribution of the Wald test statistic under the null is non-standard Chi-Square involving nuisance parameters, and therefore standard critical values are not applicable (see Toda and Phillips, 1993).

4.2 Unit Root Tests for Stationarity

Table 1 gives the results of ADF unit root tests with lag lengths chosen by downward search (AIC t-test on the longest lag). The null hypothesis of a unit root is not rejected for any of the level variables. However, each of the logged series is stationary in first differences, so it appears that all the variables are integrated of order one.

Table 1: ADF tests for Unit Root

Null Hypothesis: each series contains a unit root

Variables	ADF(include trend) Level	ADF(intercept only) 1st Difference.
lnGDPPC	-1.98 (4)	-3.46* (3)
lnH	-2.23(4)	-3.18**(3)
lnGX/GDP	-2.06(4)	-3.68**(4)
lnFDI/GDP	-3.13 (0)	-6.67** (3)
lnFDI/GDP*lnH	-2.84(0)	-10.35***(0)
lnI/GDP	-0.34(4)	-2.27*(4)
lnEX/GDP	-4.51(4)	-4.95**(4)
lnIM/GDP	-2.94(4)	-3.80**(3)
lnOPEN	-2.94(4)	-3.80**(3)

Note: 1. ** and * denote significance at the 1% and 5% levels, respectively.

2. Figures in parentheses are the number of lags used.

4.3 Testing for Cointegration

The results of Johansen tests between pairs of variables, shown in Table 2, reveal that the null hypothesis of no cointegration is not rejected at the 5% level, except for per capita GDP (GDPPC) and schooling (H), and GDPPC and government expenditure (GX). Between pairs of variables, there is at most one cointegrating vector, if it exists. One reason for lack of cointegration among the pairs is the omission of the relevant conditioning variables, whose inclusion makes cointegration otherwise possible (as noted in Table 3 below). Although this may seriously bias the outcome of bivariate causality tests reported below, it seems sensible to proceed by checking for cointegration and causality among the minimal set of variables first, and then progressively increase the number of variables to ensure that causality inferences drawn from the empirical analysis are not model specific.

Table 2. Johansen tests for pairwise cointegration

Cointegration Rank Test (VAR lag length = 4)						
Pair 1	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.07	7.26	15.41	7.23	14.07
lnFDI*H/GDP	At most 1	0.00	0.02	3.76	0.02	3.73
Pair 2	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.07	8.91	15.41	8.58	14.07
LnFDI/GDP	At most 1	0.00	0.33	3.76	0.33	3.73
Pair 3	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.2	15.81*	15.41	15.63*	14.07
LnH	At most 1	0.01	1.43	3.76	1.43	3.73
Pair 4	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.13	16.66*	15.41	15.65*	14.07
LnGX/GDP	At most 1	0.01	1.01	3.76	1.01	3.73
Pair 5	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.10	12.57	15.41	11.69	14.07
LnI/GDP	At most 1	0.01	0.88	3.76	0.88	3.73
	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
Pair 6						
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.08	10.54	15.41	9.19	14.07
LnIM/GDP	At most 1	0.01	1.36	3.76	1.36	3.73
	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
Pair 7						
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.09	11.48	15.41	9.66	14.07
LnEX/GDP	At most 1	0.02	1.82	3.76	1.82	3.73
	Hypothesized No.	Eigenvalue	Trace	5%	Max-Eigen	5%
Pair 8						
	of CE(s)		Statistic	Critical value	Statistic	Critical value
LnGDPPC	None	0.08	10.54	15.41	9.19	14.07
LnOPEN	At most 1	0.01	0.01	3.76	1.36	3.73

Note: The order of the VAR lag length is set to 4 (following the AIC criterion), although results for other lag lengths (orders 2, 3, and 5) have not affected the conclusions.

Since H and GX individually appear to be cointegrated with GDPPC, it is sought to extend the number of variables including these three and check for cointegrating combinations. Table 4 reports the number of cointegrating vectors for various sets of VAR models that commonly include (logs of) GDPPC (as the dependent variable) and H, I and GX (as the minimal set of conditioning variables). As stated earlier, causality tests are to be carried out on a variety of VAR/VECM specifications in order to check for the robustness of the results.

Table 3. Cointegrating Vectors

VAR Specification (Lag Length=4)	No. of Coingetrating vectors significant at 5 % level (1 % level in parenthesis)		
VAR Model (all variables in logs)	Trace	λ_{Max}	No. used in VECM
1: GDPPC, H, I/GDP, GX/GDP, and FDI/GDP	2(1)	1(0)	1
2: GDPPC, H, I/GDP, GX/GDP, FDI/GDP, and FDI/GDP*H	2(1)	1(1)	1
3: GDPPC, H, I/GDP, GX/GDP, and EX/GDP	3(2)	1(0)	2
4: GDPPC, H, I/GDP, GX/GDP, IM/GDP, and EX/GDP	3(3)	3(0)	3
5: GDPPC, H, I/GDP, GX/GDP, EX/GDP, and FDI/GDP	2(1)	0(0)	1
6: GDPPC, H, I/GDP, GX/GDP, OPEN, and FDI/GDP	2(1)	1(1)	1
7: GDPPC, H, I/GDP, GX/GDP, OPEN, and FDI/GDP*H	2(1)	1(1)	1
8: GDPPC, H, I/GDP, GX/GDP, OPEN, FDI/GDP and FDI/GDP*H	2(2)	2(2)	2
9: GDPPC, H, I/GDP, GX/GDP, EX/GDP, FDI/GDP, and FDI/GDP*H	3(2)	2(2)	2
10: GDPPC, H, I/GDP, GX/GDP, EX/GDP, IM/GDP, FDI/GDP and FDI/GDP*H	4(3)	2(2)	3

It can be seen that cointegrating combinations exist between GDPPC, FDI and EX with the addition of H, GX and I as conditioning variables. Although the results of Trace and λ-max statistics differ in terms of the number of cointegrating combinations, the addition of imports (IM) to the VAR specification clearly increases the cointegration space, as can be noted from the comparison of results between the successive rows 3 & 4, 9 &10. This is noteworthy, as the results of single equation estimation reported below reveals that imports is a significant determinant of per capita GDP growth, and therefore its omission from the analysis may seriously bias the outcome of causality tests. Thus, we consider causality tests for numerous sets of variables, both with and without the imports variable, and check for potential biases. The final column of Table 4 states the number of cointegrating vectors to be chosen for VECM estimation, largely based on the results of the Trace statistic (at 1% level), although it could be argued that our choice more appropriately represents a half way compromise given the outcome of the two test results.

4.4 Bivariate Granger Causality Tests

To establish causal links, if any, between pair of variables, Table 4 reports the results of Wald Tests for varying VAR lag lengths (2,3,4 and 5). Given the absence of cointegration between the pairs considered, the bivariate VAR specification here is in first differenced form. The causality evidence in this context may be interpreted as occurring between growth rates. The results reveal bi-direction causality between per capita GDP and investment. There is also evidence of causality from GDP growth to exports and to imports (and so also trade openness), and some evidence of causal link in the opposite direction but this is not highly significant and is not persistent at all lag lengths. Most notable is the absence of any causal connection between FDI (and FDI*H) and per capita GDP growth.

Table 4. Granger Causality Tests Based on Unrestricted VAR

VAR Lag Length	2	3	4	5	Summary
Dependent variable: Δ (lnGDPPC)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnI/GDP)	21.16***	63.64***	27.73***	24.84***	
Dependent variable: Δ (lnI/GDP)					Bi-directional causality
Causal variable	X^2	X^2	X^2	X^2	ΔlnGDPPC ⇔ ΔlnI
Δ (lnGDPPC)	46.12***	49.67***	23.44***	14.40***	
Dependent variable: Δ (lnGDPPC)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnEX/GDP)	3.44	3.22	7.20*	11.87*	
Dependent variable: Δ (lnEX/GDP)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnGDPPC)	3.53	4.29	2.11	2.30	No causal link
Dependent variable: Δ (lnGDPPC)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnIM/GDP)	0.88	8.57**	4.95	6.52	
Dependent variable: Δ (lnIM/GDP)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnGDPPC)	0.89	11.94***	4.79	3.90	ΔlnGDPPC ⇔ ΔlnIM
					At lag length 3 only
Dependent variable: Δ (lnGDPPC)					
Causal variable	X^2	X^2	X^2	X^2	ΔlnGDPPC ⇔ ΔlnOPEN
Δ (lnOPEN/GDP)	0.89	8.57**	4.95	6.51	At lag length 3 only
Dependent variable: Δ (lnOPEN/GDP)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnGDPPC)	16.19***	11.94***	4.79	3.90	ΔlnGDPPC ⇒ ΔlnOPEN
					At lag length 2 only

Dependent variable: Δ (lnGDPPC)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnFDI/GDP)	1.21	1.58	2.17	3.38	No causal link
Dependent variable: Δ (lnFDI/GDP)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnGDPPC)	0.50	0.42	2.47	2.90	No causal link
Dependent variable: Δ (lnGDPPC)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (lnFDI/GDP*lnH)	2.67	3.29	3.60	5.44	No causal link
Dependent variable: Δ (lnFDI/GDP*lnH)					
Causal variable	X^2	X^2	X^2	X^2	
Δ (GDPPC)	1.22	1.25	2.70	3.24	No causal link

Note: * , ** and * denote significance at the 10% , 5% and 1% levels, respectively.**

4.5 Weak Causality Tests

Table 5 reports the outcome of weak causality tests, conducted within a VECM formulation, for all the specifications listed in Table 4. As noted earlier, absence of weak causality (equivalent to weak exogeneity of a conditioning variable with respect to the cointegrating parameters in the VECM model) implies that the short run behaviour of the variable in question is not affected by co-movement of other variables in the system. This is a sufficient (but not necessary) condition for non-causality in VECM models (Toda and Phillips, 1993). Failure to reject weak causality implies, in turn, that there is evidence of bi-directional Granger causality between the given set of cointegrating variables. The null hypothesis of weak non-causality cannot be rejected for most of the variables, specifically for VECM models 8, 9 and 10. The only variable for which the rejection frequency is high across most models is government expenditure (GX), although even this is not rejected in model 10.[5] Note also that the null hypothesis for weak non-causality is not rejected for GDPPC, suggesting that it would be appropriate to base inferences about non-causality from other variables to GDPPC (except for model 1 where this test is rejected).

[5] The outcome of this test implies that, since most variables, in particular FDI, FDI*H, EX, IM, H and I are weakly exogenous, it is valid to condition on these variables when estimating a single equation ECM for GDPPC.

Table 6. Weak Causality Tests
(H_0: the appropriate row of matrix α being zero)

VECM Model 1.				**VECM Model 2.**			
Lag length (4)	LR Test	p-value	Decision (H_0)	Lag length (4)	LR Test	p-value	Decision (H_0)
GDPPC	3.28	0.07	R	GDPPC	0.19	0.66	A
H	0.27	0.60	A	H	0.97	0.32	A
I/GDP	0.04	0.84	A	I/GDP	0.35	0.56	A
GX/GDP	12.53	0.00	R	GX/GDP	13.81	0.00	R
FDI/GDP	0.01	0.92	A	FDI/GDP	2.36	0.12	A
				FDI/GDP*H	1.58	0.21	A
VECM Model 3.				**VECM Model 4.**			
Lag length (4)	LR Test	p-value		Lag length (4)	LR Test	p-value	
GDPPC	1.14	0.29	A	GDPPC	0.83	0.36	A
H	2.60	0.11	A	H	0.78	0.38	A
I/GDP	0.46	0.50	A	I/GDP	0.16	0.69	A
GX/GDP	7.32	0.01	R	GX/GDP	2.29	0.13	A
EX/GDP	0.09	0.76	A	IM/GDP	2.03	0.15	A
				EX/GDP	0.31	0.58	A
VECM Model 5.				**VECM Model 6.**			
Lag length (4)	LR Test	p-value		Lag length (4)	LR Test	p-value	
GDPPC	0.08	0.78	A	GDPPC	0.17	0.68	A
H	0.03	0.87	A	H	0.17	0.68	A
I/GDP	0.71	0.40	A	I/GDP	0.65	0.42	A
GX/GDP	8.22	0.00	R	GX/GDP	19.24	0.00	R
EX/GDP	2.32	0.13	A	OPEN	4.55	0.03	R
FDI/GDP	0.00	0.98	A	FDI/GDP	1.30	0.25	A
VECM Model 7.				**VECM Model 8.**			
Lag length (4)	LR Test	p-value		Lag length (4)	LR Test	p-value	
GDPPC	0.31	0.58	A	GDPPC	0.64	0.42	A
H	0.25	0.62	A	H	1.88	0.17	A
I/GDP	0.58	0.44	A	I/GDP	0.61	0.92	A
GX/GDP	17.45	0.00	R	GX/GDP	3.08	0.08	R
OPEN	4.65	0.03	R	OPEN	1.96	0.16	A
FDI/GDP*H	1.07	0.30	A	FDI/GDP	2.04	0.15	A
				FDI/GDP*H	1.33	0.25	A
VECM Model 9.				**VECM Model 10.**			
Lag length (4)	LR Test	p-value		Lag length (4)	LR Test	p-value	
GDPPC	0.96	0.33	A	GDPPC	0.22	0.64	A
H	0.88	0.35	A	H	0.14	0.71	A
I/GDP	0.18	0.67	A	I/GDP	0.00	0.97	A
GX/GDP	3.70	0.05	R	GX/GDP	0.17	0.68	A
EX/GDP	0.01	0.93	A	EX/GDP	0.08	0.78	A
FDI/GDP	1.47	0.23	A	IM/GDP	0.03	0.85	A
FDI/GDP*H	0.90	0.34	A	FDI/GDP	0.37	0.54	A
				FDI/GDP*H	0.34	0.56	A

Note: R denotes rejection, A acceptance, of the null.

4.6 Multivariate Granger Causality Tests

The results of Wald tests, reported in Table 6, are for the null hypothesis that all higher order lagged coefficients of the relevant causal variable in the VECM are jointly zero. These comprise the second set of restrictions implied by Granger non-causality.[6] They are conducted pairwise, so that for each dependent variable the reported values are the Chi-square statistics for the relevant causality test taking each causal variable in succession. Thus, the values down the columns are the results of all causality tests based on a given VECM model, while the values along the rows are the results for a given causality test conducted for all models. This way of presenting the results makes comparisons across models easier.

Evidence of bi-directional causality between domestic investment and per capita GDP growth is confirmed here in the multivariate case too (see the first and the third blocks of Table 6). Of particular interest are the results of the Granger causality tests on GDPPC, which reveal that domestic investment (I) and exports (EX) are the main causal effects on growth across most VECM specifications. Notice that imports do not affect growth directly, implying that the direct significance of trade openness on growth comes mainly through exports. This may lend credence to the export-led growth hypothesis for Thailand, although causality tests on what causes investment growth reveal that imports might have an indirect effect on growth through its impact on domestic investment. The same goes for human capital, which does not directly affect growth but may be having an indirect effect given evidence of its bi-directional causality with domestic investment (across most specifications). Most noteworthy is lack of causality from FDI to growth, directly or indirectly through domestic investment. Whatever impact FDI is having on growth appears to come through it impact on human capital (and also apparently through government consumption), although evidence for this is not quite robust.

Direct support for growth led-FDI hypothesis is also weak, although indirect effect may be coming through the causal links from domestic investment and exports to FDI, reinforced by bi-directional causality between GDP growth and investment. However, there is a significant impact of growth and FDI on government expenditure, a finding possibly explained by recent investments in public infrastructure (including

[6] Hence, as stated earlier, inference on Granger non-causality is conditional on the acceptance of weak non-causality, although estimation of VECM does not impose this long run restriction.

education) fuelled by the availability of foreign capital and joint ventures with foreign multinationals. But there is little in the data to suggest that this has affected economic growth directly, although the causality tests show that government expenditure has significantly influenced the development of human capital in Thailand.

Table 6. Multivariate Granger Causality Tests

Granger causality tests: Dependent variable ΔlnGDPPC										
VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnH	1.25	0.68	2.95	3.02	1.50	1.21	1.31	0.15	0.61	0.50
ΔlnI/GDP	18.67***	10.99**	20.55***	19.30***	16.54***	22.86***	22.34***	18.76***	13.89***	13.31***
ΔlnGX/GDP	1.03	3.56	2.97	3.59	3.74	3.73	3.63	5.76	6.44	7.38
ΔlnIM/GDP				1.79						2.32
ΔlnEX/GDP			13.51***	6.74	8.62*				12.96***	5.33
ΔlnOPEN						7.14	6.47	9.32**		
ΔlnFDI/GDP	4.64	2.56			0.70	1.69		2.46	4.85	4.18
ΔlnFDI*lnH/GDP		3.13					2.14	2.80	5.18	4.41
Granger causality tests: Dependent variable ΔlnH										
VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC	1.75	1.49	2.73	4.80	1.69	5.05	4.89	4.98	1.57	4.15
ΔlnI/GDP	3.07	2.95	7.75	12.66***	3.30	8.36*	8.26*	10.24**	3.37	8.81*
ΔlnGX/GDP	15.23***	14.85***	16.54***	13.87***	14.55***	11.23**	11.67**	14.33***	14.64***	12.12**
ΔlnIM/GDP				6.91						7.67*
ΔlnEX/GDP			2.46	1.13	2.01				1.82	1.38
ΔlnOPEN						7.33	7.41	9.12*		
ΔlnFDI/GDP	10.14	0.98			10.22**	12.23**		2.18	0.56	1.67
ΔlnFDI*lnH/GDP		0.96					12.82***	2.35	0.68	1.93
Granger causality tests: Dependent variable ΔlnI/GDP										
VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC	3.66	1.81	5.44	8.28*	4.62	5.20	5.10	5.20	4.14	6.49
ΔlnH	6.60	7.22	5.49	10.10**	7.31	11.01**	11.01**	9.85**	7.36	11.21**
ΔlnGX/GDP	1.98	3.01	1.53	1.09	1.53	0.97	1.07	1.74	3.31	2.55
ΔlnIM/GDP				13.86***						13.32***
ΔlnEX/GDP			4.86	5.80	5.14				6.71	5.83
ΔlnOPEN						10.12**	10.27**	13.91***		
ΔlnFDI/GDP	2.70	6.50			3.14	1.62		5.24	5.86	5.03
ΔlnFDI/GDP*lnH		7.39					2.25	6.42	6.79	5.83
Granger causality tests: Dependent variable ΔlnGX/GDP										
VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC	17.99***	19.31***	13.65***	12.79***	14.98***	20.65***	20.38***	16.21***	12.90***	11.64**
ΔlnH	1.97	14.68***	3.91	3.44	5.52	5.05	2.86	10.21**	12.26**	8.50*
ΔlnI/GDP	6.60	6.43	7.72	0.94	8.94*	2.06	2.02	1.20	7.48	2.39
ΔlnIM/GDP				7.35						4.91
ΔlnEX/GDP			4.19	8.99*	6.58				9.96**	8.03*
ΔlnOPEN						11.14**	11.40**	6.88		
ΔlnFDI/GDP	2.48	21.50***			4.08	9.06*		16.91***	18.09***	13.76***
ΔlnFDI/GDP*lnH		20.45***					6.46	16.35***	18.03***	13.62***
Granger causality tests: Dependent variable ΔlnIM/GDP										

VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC				5.71						3.30
ΔlnH				12.74***						9.66**
ΔlnI/GDP				22.79***						19.93***
ΔlnGX/GDP				4.14						4.51
ΔlnEX/GDP				4.37						6.12
ΔlnOPEN										
ΔlnFDI/GDP										0.99
ΔlnFDI/GDP*lnH										0.75

Granger causality tests: Dependent variable ΔlnEX/GDP

VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC			4.15	2.68	7.66*				2.81	3.18
ΔlnH			3.98	1.80	7.47				3.12	2.46
ΔlnI/GDP			3.71	7.07	6.08				6.54	7.87
ΔlnGX/GDP			8.30	5.43	10.60**				5.60	3.67
ΔlnIM/GDP				3.06						5.62
ΔlnOPEN										
ΔlnFDI/GDP					8.05*				3.68	3.88
ΔlnFDI/GDP*lnH									3.14	3.16

Granger causality tests: Dependent variable ΔlnOPEN

VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC						6.11	6.03	4.54		
ΔlnH						15.53***	14.41**	9.68**		
ΔlnI/GDP						23.79***	23.89***	19.62***		
ΔlnGX/GDP							5.37	4.13		
ΔlnIM/GDP										
ΔlnEX/GDP										
ΔlnFDI/GDP						6.44		0.65		
ΔlnFDI/GDP*lnH							6.78	0.59		

Granger causality tests: Dependent variable ΔlnFDI/GDP

VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC	0.59	0.59			0.74	0.38		0.46	0.62	1.10
ΔlnH	1.01	2.62			3.60	2.68		3.83	5.41	5.64
ΔlnI/GDP	5.41	5.94			10.26**	8.61*		9.09*	10.57**	10.24**
ΔlnGX/GDP	3.71	1.17			7.53	1.81		1.47	6.81	6.47
ΔlnIM/GDP										2.46
ΔlnEX/GDP					14.84***					17.49***
ΔlnOPEN						1.97		4.87	20.66***	
ΔlnFDI/GDP*lnH		3.28						3.99	4.27	4.18

Granger causality tests: Dependent variable ΔlnFDI*lnH/GDP

VAR lag length = 4										
Model	1	2	3	4	5	6	7	8	9	10
ΔlnGDPPC		0.25					0.31	0.31	0.48	0.82
ΔlnH		2.10					2.77	3.18	4.69	4.79
ΔlnI/GDP		6.14					9.25*	9.68**	10.74**	10.87**
ΔlnGX/GDP		2.07					2.68	2.39	8.54*	8.08*
ΔlnIM/GDP										2.60
ΔlnEX/GDP									19.65***	16.33***
ΔlnOPEN							1.97	5.09		16.32***
ΔlnFDI/GDP		4.04						4.80	5.10	5.11

5. Single Equation Estimation

This section reports the estimates of an error correction model for per capita GDP in order to identify the magnitude of the causal influences in both the short run and the long run. Estimation is by two-step Engle-Granger procedure (Engle and Granger (1987)), where the lagged residual of the static regression is incorporated as the error correction term in the regression of first differences, given cointegration among the variables. Table 7 reports various estimated versions of the static regression, while the estimates of the error correction counterpart are reported in Table 8[7]. Despite the obvious limitation of this exercise and potential biases of the estimates, static regression allows calculation of the threshold value of human capital on which the effect of FDI is determined.

Another way of distinguishing between the results of Table 7 and 8 is that former indicates the relationship in levels while the latter is interpreted in terms of growth rates. Thus the error correction form facilities testing of the export-led and FDI-led hypotheses in term of growth rates, while observing the constraints imposed in the long run through cointegration among the variables.

Table 7. THAILAND: OLS Regressions: 1973:2-2000:4 Dependent variable is lnGDPPC,											
Regressor	**7.1**	**7.2**	**7.3**	**7.4**	**7.5**	**7.6**	**7.7**	**7.8**	**7.9**	**7.10**	**7.11**
Constant	8.02	9.96	8.30	9.01	8.02	8.39	4.10	4.08	5.77	9.88	9.96
	(18.66)	(31.51)	(26.68)	(28.64)	(21.37)	(20.35)	(12.49)	(10.26)	(10.05)	(29.25)	(30.41)
***Ln*H**	1.07	-1.96	0.82	1.01	0.92	0.77	0.56	0.65	-0.38	-1.85	-1.39
	(5.35)	(-7.12)	(5.14)	(6.74)	(5.22)	(3.33)	(5.09)	(4.66)	(-1.31)	(-5.82)	(-4.02)
***ln*I/GDP**	0.22	0.24	0.15	-0.09	0.14	0.16	-0.13	-0.14	-0.04	0.23	0.09
	(5.11)	(8.46)	(3.95)	(-1.51)	(3.45)	(3.83)	(-4.23)	(-4.10)	(-0.97)	(7.28)	(1.65)
***Ln*IM/GDP**				0.51							0.26
				(5.02)							(2.96)
***Ln*EX/GDP**			0.22	-0.09	0.24	0.21				0.02	-0.10
			(5.79)	(-1.33)	(5.83)	(4.70)				(0.64)	(-1.78)
***lnO*PEN/GDP**							0.38	0.38	0.28		
							(10.55)	(15.36)	(8.09)		
***ln*GX/GDP**	-0.02	-0.09	-0.16	-0.16	-0.18	-0.16	-0.18	-0.18	-0.17	-0.11	-0.12
	(-0.44)	(-3.31)	(-3.64)	(-3.84)	(-3.87)	(-3.29)	(-7.27)	(-7.08)	(-6.93)	(-3.03)	(-3.38)
***ln*FDI/GDP**	0.02	-0.52			-0.02		-0.03		-0.21	-0.50	-0.44
	(1.05)	(-11.65)			(-1.30)		(-2.99)		(-3.95	(-9.68)	(-8.22)
***Ln*FDI/GDP**		0.34				0.00		-0.01	0.12	0.32	0.28
		(2.42)				(0.35)		(-2.35)	(3.47)	(9.53)	(7.88)
Adjust R^2	0.95	0.98	0.96	0.97	0.96	0.96	0.98	0.98	0.99	0.98	0.98

[7] In this estimation we have also included the joint influence of exports and imports through a variable constructed as *OPEN=(EX+IM)/GDP* to replace the individual variables *EX* and *IM*. ADF and Johansen tests confirm this variable to be I(1) and cointegrated with the other variables.

S.E.	0.1	0.07	0.09	0.08	0.09	0.09	0.05	0.06	0.05	0.07	0.06
Ed. Threshold(FDI)		4.81							5.75	4.76	4.8

Note: The threshold values are calculated as follows. Consider ln *X* and ln *X* * ln *H* as the two regressors with estimates $\hat{\alpha}$ and $\hat{\beta}$, where one is positive and the other negative. To calculate the minimum level at which the overall effect is positive, put $\hat{\alpha}\ln X + \hat{\beta}\ln X * \ln H = 0$, so that ln *H* = $-\hat{\alpha}/\hat{\beta}$, or *H* = antilog $(-\hat{\alpha}/\hat{\beta})$.

Table 8. THAILAND: OLS Regressions: 1973:3-2000:4 Dependent variable is ΔlnGDPPC,											
Regressor	**8.1**	**8.2**	**8.3**	**8.4**	**8.5**	**8.6**	**8.7**	**8.8**	**8.9**	**8.10**	**8.11**
Constant	0.02	0.01	0.02	0.01	0.02	0.02	0.00	0.00	0.00	0.01	0.01
	(3.85)	(2.81)	(3.24)	(2.73)	(3.24)	(3.25)	(1.24)	(1.28)	(1.02)	(2.47)	(2.04)
Δ*ln*H	-0.44	-0.12	-0.10	-0.13	-0.09	-0.17	0.15	0.17	0.49	-0.07	0.33
	(-0.56)	(-0.15)	(-0.14)	(-0.18)	(-0.12)	(-0.22)	(0.28)	(0.31	(0.84)	(-0.08)	(0.45)
Δ*ln*I/GDP	-0.10	-0.09	-0.12	-0.21	-0.12	-0.12	-0.21	-0.21	-0.21	-0.10	-0.20
	(-4.01)	(-3.18)	(-4.77)	(-7.94)	(-4.85)	(-4.77)	(-11.09)	(-11.13)	(-10.61)	(-3.63)	(-7.00)
Δ*ln*IM/GDP				0.23							0.23
				(5.71)							(5.58)
Δ*ln*EX/GDP			0.05	-0.03	0.05	0.05				0.04	-0.03
			(1.95)	(-1.04)	(1.86)	(1.83)				(1.61)	(-1.19)
Δ*ln*OPEN/GDP							0.24	0.25	0.25		
							(10.42)	(10.40)	(0.40)		
Δ*ln*GX/GDP	-0.09	-0.09	-0.08	-0.05	-0.08	-0.08	-0.02	-0.12	-0.02	-0.09	-0.05
	(-3.67)	(-1.34)	(-3.39)	(-2.11)	(-3.42)	(-3.41)	(-1.02)	(-0.98)	(-1.08)	(-3.66)	(-2.28)
Δ*ln*FDI/GDP	0.01	-0.09			0.01		-0.01		0.02	-0.09	-0.03
	(1.06)	(-1.34)			(0.58)		(-1.17)		(0.35)	(-1.29)	(-0.43)
Δ(*ln*FDI/GDPln*H**		0.07				0.01		-0.01	-0.02	0.06	0.02
		(1.44)				(0.82)		(-1.21)	(-0.53)	(1.36)	(0.36)
ECM_{t-1}	-0.08	-0.14	-0.08	-0.10	-0.08	-0.08	-0.11	-0.11	-0.12	-0.14	-0.14
	(-2.53)	(-2.55)	(-2.19)	(-2.54)	(-2.18)	(-2.18)	(-2.54)	(-2.49)	(-2.71)	(-2.66)	(-3.01)
Adjust R^2	0.41	0.41	0.41	0.53	0.41	0.41	0.69	0.69	0.69	0.42	0.53
S.E.	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03

The main conclusions from the results in Tables 7 and 8 may be summarised as follows.

1. The effect of government expenditure on income and growth is negative and almost always significant, as expected, across all estimated specifications.

2. The effect of *FDI* on growth is not robustly significant, although remains positive in the short run but over the longer term turns mostly negative. This perverse result, however, may be the result of multicollinearity caused the inclusion of both FDI and FDI*H which are highly correlated in both levels and growth rates. However, the inclusion of both these terms in the regression is necessary to determine the education threshold, found to be approximately 4.5 years average attainment level of secondary education, beyond which the negative effect of *FDI* is offset by the positive effect of *FDI*H*.
3. Exports generally have a positive effect on both income and growth, except when controlling for imports growth, as the effect of exports is insignificant when the imports variable is also included in the regression.
4. Imports have a positive and significant effect on income and growth, its effect being persistent in both the short run and long run. The inclusion of imports also improves the explanatory power of the regression but at the same time renders the effect of exports and as well as domestic investment negative or insignificant. This might be a perverse result, although Granger causality tests confirm that its causal effect on GDP comes mainly through domestic investment.
5. To overcome the puzzling effect of imports, regressions 7.7-7.9 and 8.7-8.9 report estimates with the variable OPEN replacing both EX and IM variables, thus estimating the overall effect of trade openness, which is compared with the effect of FDI. The results clearly suggest that trade openness has significantly influenced both income and growth, while the effect of FDI is largely insignificant.
6. The effect of human capital on income and growth is ambiguous but clearly positive in the absence of the interaction term FDI*H, and negative otherwise. However, the negative coefficient on human capital is not unusual, owing to the possibility of high fixed costs in the initial production of human capital, high opportunity cost in terms of output of educating child workers, and cost involved in the interaction of educated and non-educated workers (Evans, Green and Murinde (2002)).

5. Conclusion

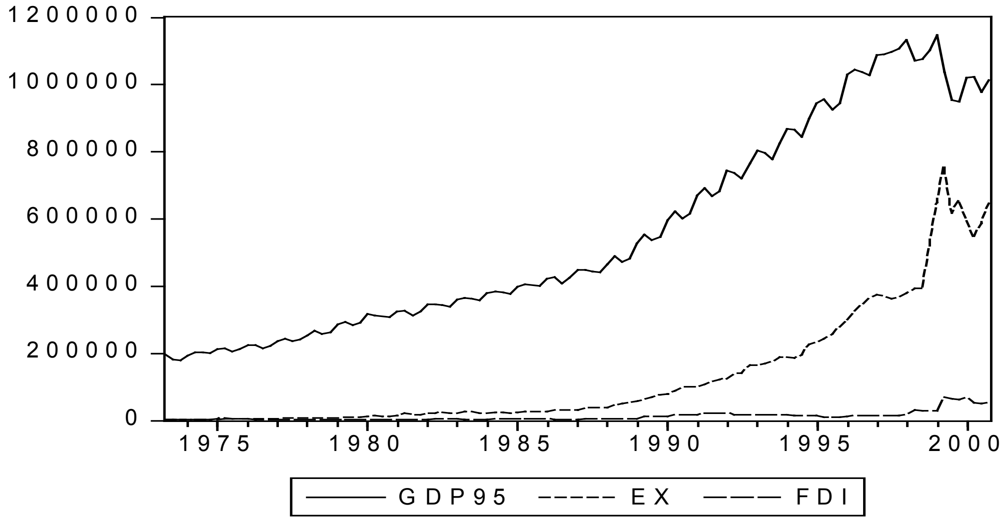
This paper has conducted Granger causality tests across a variety of specifications within a VAR/VECM framework. The main contribution of the paper has been identify causal links among factors affecting and affected by economic growth in Thailand, including the formal investigation of the export-led and FDI-led growth hypotheses, using quarterly data over the period 1973:2-2000:4.

The empirical analysis has involved, after testing the integration and cointegration properties of the data, investigation of causality links between pairs of variables as well as among sub-sets of variables in a multivariate setting. The main issue here has been to ensure that causality inferences drawn for the empirical analysis are robust with respect to changes in the VAR/VECM specifications

Taken together, the results have revealed strong support for the claim that economic growth in Thailand has been driven largely by domestic investment growth, as would be expected, but also that domestic investment has been fuelled by economic growth. Controlling for domestic investment growth as well as other factors, causality tests also show support for the export-led growth hypothesis, but not for FDI-led growth in Thailand. Support for this claim is also shown in the bivariate causality tests, although in a multivariate context it has been possible to identify other possible linkages. For example, multivariate tests results have shown that imports have not contributed to growth directly, but its effect is coming indirectly through domestic investment. In this way, trade openness has complemented domestic investment in fuelling economic growth in Thailand.

One possible explanation for the weak FDI effect is that the upsurge in FDI inflows to Thailand is rather more recent in the data for the effect to be significant over the period of investigation (see Figure 1). By contrast, exports have seen steady growth over the 1990s. Thus, in the case of Thailand, which has pursued a deliberate policy of the export promotion (EP) since 1972 and FDI promotion since 1997, it is perhaps not surprising to find that evidence for export-led growth is strong while that for FDI-led growth is weak.

Figure 1. Thailand's Key Economic Indicators (Million of Baht)



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