CHAPTER 4

ECONOMETRIC RESULTS

This chapter examines the causality relationship between financial development and growth. It begins with discussion of the model specification, followed by data sources and econometric procedure in Section 4.2. In Section 4.3, econometric results are presented and interpreted.

4.1 The Model

In this study, the endogenous growth model is employed. As discussed in Chapter 2, financial development could promote investment expansion as well as finance more innovative projects to be carried out. It is unlikely that technological progress is exogenous as postulated in the Neoclassical growth model. To illustrate the role of financial development on growth, we follow Pagano (1993) and Montiel (2003) in which the AK model of Rebelo (1991) is used. In this model, only capital (K_t) is the only production factor under conditions of constant returns to scale (CRS). Thus, the aggregate production function is expressed as:

$$Y = AK_t \tag{4.1}$$

where Y and A represent output and total factor productivity, respectively.

Assume that capital depreciates at a rate of δ so that $K_{t+1} = I_t + (1-\delta)K_t$. In addition, we assume no population growth. Hence the model can be expressed in terms of per capita. Note that in Equation 4.1, aggregate output is a linear function of reproducible factors of production, implying that an increase in such factors is not subject to diminishing returns. This is not a restrictive assumption as diminishing returns might occur at the firm level. However, diminishing returns could disappear in the aggregate level due to externalities affecting the physical capital stock or diminishing returns may apply to physical and human capital separately, but not to their composite if there is human capital as a production factor (Montiel, 2003).

It is also assumed a certain proportion of savings, the size of $(1-\phi)$, is the cost of financial intermediation per unit of savings, in the form of spreads between borrowing and lending rates, transaction fees and so on, which are the resource absorbed in producing intermediation services. Only the fraction (ϕ) of total savings can be used to finance investment. Such spreads could indicate inefficiency in the financial systems. The lesser the spreads, the more efficient the financial system is. Therefore, the saving-investment relationship can be written as $I_t = \phi S_t$. The economic growth rate (g_y) can be expressed as:

$$g_y = g_A + g_K \tag{4.2}$$

where $$g_K = \frac{K_{t+1} - K_t}{K_t} = \frac{I_t + (1-\delta)K_t - K_t}{K_t} = \frac{\theta S_t}{K_t} - \delta = A\phi s_t - \delta$$

$$s_t = S_t / Y_t = S_t / AK_t .$$

Equation 4.2 expresses that economic growth depends on the total factor productivity (A), the efficiency of financial intermediation (ϕ), and the rate of savings(s). When the rate of depreciation (δ) is assumed to be constant, economic growth depends on financial development. Note that one shortcoming of the model is that it represents a closed economy, and so does not take into account the capital flows. To rectify such a shortcoming, trade openness is included. While a positive relationship between trade and economic growth is well documented in the literature (Edwards, 1998), the recent studies (e.g. Beck 2002 ; Do and Levchenko, 2004) show that trade openness, finance and growth are interrelated. In particular, Beck (2002) demonstrated that financial development results in higher level of exports and trade balance of manufactured goods which, in turn, imply higher economic development. Similarly, Do and Levchenko (2004) predicted that trade is positively associated with financial system expansion in countries with higher level of economic development.

Hence, the final model is specified as follows:

Model: $F = f(G,T)$

Model: $G = f(F,T)$

where *F* = the composite indicator of financial development

G = per capita real GDP.

T = trade openness

4.2 Data Sources and Econometric Procedure

Private credit (*P*), liquid liabilities (*M*), commercial bank assets (*A*) and trade openness (*T*) are from International Financial Statistics, International Monetary Fund (IMF), CD-ROM whereas GDP and GDP per capita (*G*) are from Annual report (various issues), Bank of Thailand. All variables are in natural logarithms expressed in local currency (except for *RULE*) so that first differencing can convert them into growth rates. Table 4.1 summarizes the variable measurement and data sources.

Econometric procedure in this thesis starts with examining time series properties of each variable. Most economic time series tend to be non-stationary (because they grow over time and so do not have a fixed, "stationary" mean). Running ordinary least square estimation of non-stationary variables would give spurious regression outcome and meaningless results involving invalid inferences based on *t*-tests and *F*-tests. The spurious is characterized by high R-square and significant t-statistics on the estimated coefficients, but having low Durbin-Watson statistic due to high degree autocorrelations in estimated residuals. Therefore, in general practice of time series econometric analysis, test for the presence of unit roots is undertaken. In this study, Augmented Dickey-Fuller (ADF) tests are conducted.[1]

[1] See the detailed discussion of ADF tests in Appendix B.

Table 4.1

Variable Measurement and Source of Data

Source	Variable	Measurement
	private credit (*P*)	Ln (domestic credit to private sector/ nominal GDP) -Domestic credit to private sector is the credit issued by banks and other financial institutions provided to private sector such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable that establish a claim for repayment.
	liquid liabilities (*M*)	Ln (liquid liabilities/nominal GDP) -Liquid liabilities are the sum of currency in circulation, deposits at commercial banks, promissory notes issued by finance companies, deposits at specialized banks and securities issued by commercial banks.
IMF's International Financial Statistics (2007)	commercial bank assets (*A*)	Ln(commercial bank assets/commercial bank assets + central bank assets) -Commercial bank assets include reserves, claims on monetary authorities, claims on non-financial public enterprise, claims on private sector and claims on other financial institutions. -Central bank assets include foreign assets, claims on central government, claims on deposits money banks, claims on financial public enterprises and claims on other financial institutions.
	trade openness (*T*)	Ln (trade openness/nominal GDP) -Trade openness is the sum of exports and imports of goods and services measured as a share of gross domestic product.
Annual report's Bank of Thailand (various issues)	real GDP per capita (*G*)	Ln (real GDP per capita) -GDP per capita is gross domestic product divided by mid year population. Based year is 1988.

(Continued)

Table 4.1

Variable Measurement and Source of Data (Continued)

Source	Variable	Measurement
Annual report's Bank of Thailand (various issues)	real GDP per capita (*G*)	Ln (real GDP per capita) -GDP per capita is gross domestic product divided by mid year population. Based year is 1988.
Author's construction	rules and regulations (*RULE*)	Qualitative variable comprises of rules and regulations in Thai's financial system.
	financial development index (*F* with *RULE*)	Composite index by using principle component analysis to construct weighting scores from *P*, *M*, *A* and *RULE*.
	financial development index (*F* without *RULE*)	Composite index by using principle component analysis to construct weighting scores from *P*, *M* and *A*.

Table 4.2 presents the ADF test results of all variables used in this study. All variables are non-stationary in their levels but become stationary after taking first difference. Hence, all variables are $I(1)$ at the 5% level of significance or better. Figure 4.1 provides plots of each variable in level and first-difference during the period 1966-2005. The implication is that the set of variables taken together has the potential to form a co-integrating vector whose coefficient can directly be interpreted as long-term (steady-state) elasticities. Therefore, the model is estimated using the cointegration technique.

Table 4.2

ADF Test of All the Variables

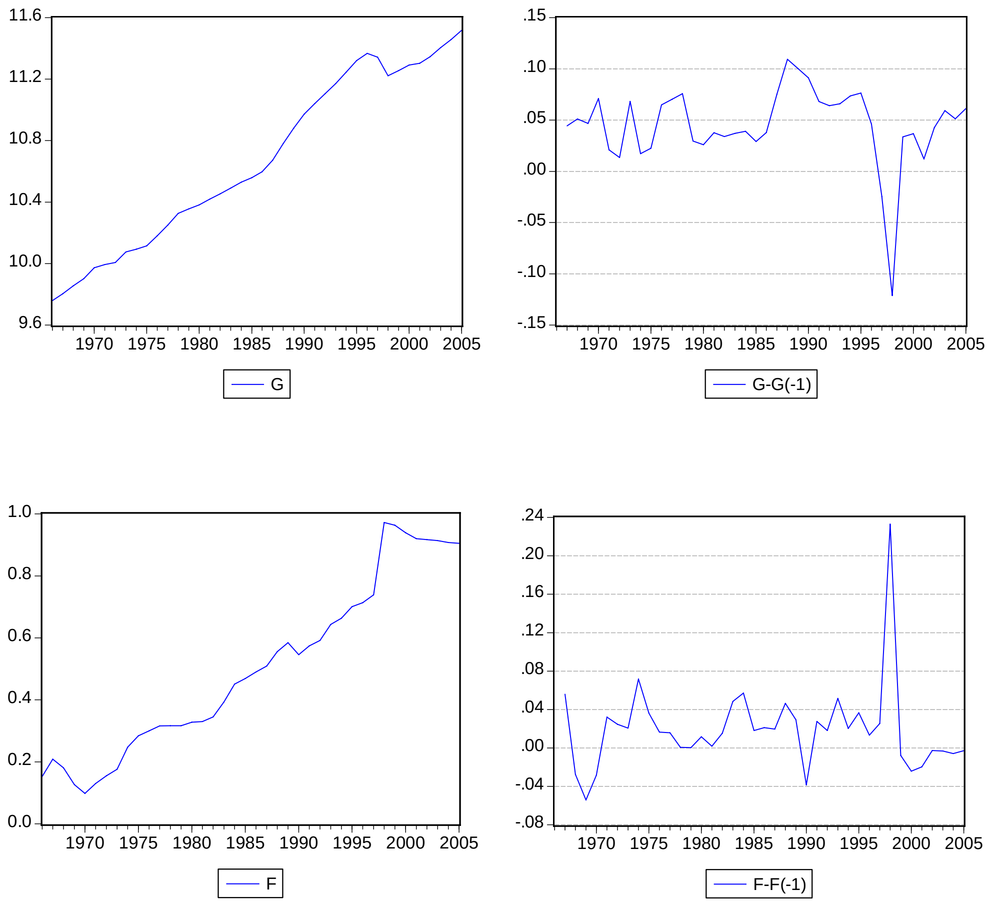
Variable	Log level	Log first difference
G	-0.569	-3.572**
F (with *RULE)*	-0.220	-5.476*
T	0.766	-5.714*

Note: 1. The Augmented Dickey-Fuller (ADF) test is under the null of a unit root with a constant and time trend. The optimal lag length for ADF regression is selected based on the AIC criterion.

2. * and ** indicate significance at the 1 % and 5% levels

Figure 4.1

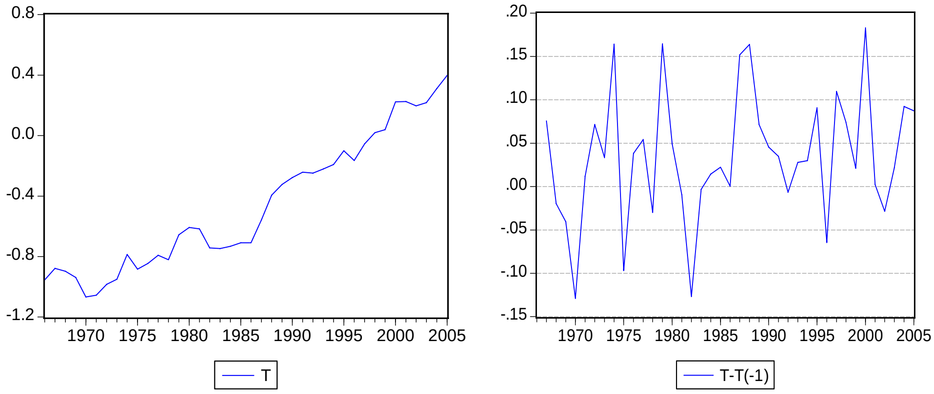
The Level and First Difference of All Variables in this Study



(Continued)

Figure 4.1

The Level and First Difference of All Variables in this Study (Continued)



Note : The pattern of the level (right) and first difference (left) of all variables in this thesis.

Although the Engle-Granger method from the co-integrating regression possesses the large sample property of consistency and is highly efficient, they are still biased in small samples. In the case of small samples, the OLS estimator has an asymptotic distribution, which is non-normal and is affected by nuisance parameters. This makes statistical inference difficult since the standard t-statistics will not be valid asymptotically. Therefore, in this thesis, the maximum likelihood method (a full parametric correction) proposed by Johansen (1988) is chosen. Under the Johansen method, the unit roots are explicitly incorporated in the specification. It also takes into account short-run dynamics in estimating the co-integrating vector, and additionally provides for testing for the existence of more than one co-integrating vector.

To examine the causality relationship between financial development and growth, Vector Error Correction Model (VECM) is selected as our preferred estimation method. While the found cointegration relationship can represent their long-run steady-state relationship, it does not contain sufficient information to indicate lead-lag relations between variables. In principle, VECM that is derived from the long-run cointegrating vectors can detect the direction of Granger causality in the sense that the VECM can capture both the short-run dynamics between variables and their long-run equilibrium relationship.

To begin, the VECM is form as follows:

$$\Delta y_t = A_0 + \Pi y_{t-1} + A_1 \Delta y_{t-1} + A_2 \Delta y_{t-2} + ... + A_{p-1} \Delta y_{t-p+1} + \varepsilon_1 \tag{4.3}$$

where Δ = Difference operator,

y_t = Column-*n* vector of endogenous variables,

$A_1,..., A_{p-1}$ = (*n*x*n*) matrices of coefficients, and

ε_t = Vector of normally and independently distributed error terms

By construction, Π has rank *r* and can be decomposed as $\Pi = \alpha\beta^{'}$. The elements of α are known as the speed of adjustment parameters, it is a (*n* x *r*) matrix where a larger α suggests a faster convergence towards the long-run equilibrium when there are short-run deviations from its equilibrium. $\beta^{'}$ is a $(n \times r)^{'}$ matrix of co-integrating vectors, that is the long-run coefficients in the VECM. Equation (4.3) can be re-written as follows:

$$\Delta y_t = A_0 + \alpha(\beta^{'} y_{t-1}) + A_t \Delta y_{t-1} + A_2 \Delta y_{t-2} + ... + A_{p-1} \Delta y_{t-p+1} + \varepsilon_t \tag{4.4}$$

For the 3-variable case with one co-integrated relationship, the VECM can be expressed as follows:

$$\Delta F_t = \mu_1 + \alpha_{11} ECT_{t-1} + \sum_{j=1}^{p-1} \phi_{1j} \Delta F_{t-j} + \sum_{j=1}^{p-1} \theta_{1j} \Delta G_{t-j} + \sum_{j=1}^{p-1} \Psi_{1j} \Delta T_{t-j} + \varepsilon_{1t} \tag{4.5}$$

$$\Delta G_t = \mu_2 + \alpha_{21} ECT_{t-1} + \sum_{j=1}^{p-1} \phi_{2j} \Delta F_{t-j} + \sum_{j=1}^{p-1} \theta_{2j} \Delta G_{t-j} + \sum_{j=1}^{p-1} \Psi_{2j} \Delta T_{t-j} + \varepsilon_{2t} \tag{4.6}$$

$$\Delta Z_t = \mu_3 + \alpha_{31} ECT_{t-1} + \sum_{j=1}^{p-1} \phi_{3j} \Delta F_{t-j} + \sum_{j=1}^{p-1} \theta_{3j} \Delta G_{t-j} + \sum_{j=1}^{p-1} \Psi_{3j} \Delta T_{t-j} + \varepsilon_{3t} \tag{4.7}$$

where T = the conditioning variables (*Trade openness*)

$\varepsilon_t{}'s$ = Gaussian residuals

ECT_{t-1} = error correction term, $F_{t-1} + (\beta_{21} / \beta_{11}) G_{t-1} + (\beta_{31} / \beta_{11}) T_{t-1}$

In other word, it is a normalized cointegration.

In addition to indicating the direction of causality among the variables, the VECM approach allows us to distinguish between the two types of Granger causality: short-run and long-run causality, namely the statistical significance of the lagged dynamic terms, and coefficient corresponding to ECT. The former measures the long-run causality relationship (i.e. the weak exogeneity test) while the latter indicate the short-run one (short-run Granger causality test).[2] Consider equation (4.5). The significance of the lagged dynamic terms by testing the null $H_0 : all\,\theta_{1j} = 0$ using the Wald test indicates whether G_t cause F_t in the short-run. Non-rejection of the null implies growth does not Granger-cause finance in the short-run. To conduct the weak exogeneity test, the statistical significance of α_{11} is examined. If α_{11} is not significantly different from zero, it implies that growth does not Granger-cause finance in the long-run.

4.3 Results from Econometric Estimation

4.3.1 Cointegration Tests[3]

The results for both $\lambda -$trace and $\lambda -$max test statistics for the number of cointegrating vectors are summarized in Table 4.3. We report test results of the financial development including and excluding rules and regulations. Both results are strikingly similar so that the following discussion focuses on the one with *RULE.* With many experiments, the model which is found most suitable is the one with a constant term in the short and long-run cointegration including dummy variable during crises (1997-98). The key inference from Table 4.2 is that there is one cointegration relationship. In other words, there is a long run relationship between financial development and economic growth.

Table 4.4 reports the cointegration estimates by normalizing the coefficient of *F* to one, we obtain the long-run elasticities of financial development with respect to other variables. Overall, all the estimated coefficients attain theoretically expected sign at the conventional level of statistical significance (i.e. 5 per cent level). The

[2] Actually, VECM can be detected by strong exogeneity test. It does not distinguish between the short-run and long run causality but it is a more restrictive test which indicates the overall causality in the system, i.e., the null hypothesis $\mathrm{H}_0 : \mathrm{all}\,\theta_{1j} = \alpha_{11} = 0$. However, strong exogeneity test will not be tested in this thesis because short and long run relationship are sufficient to indicate the causality between financial development and economic growth.

[3] See the detailed discussion of Cointegration tests in Appendix C.

cointegration relationship suggests that there is a positive relationship between output and finance in the long run. The loading factors, which measure the speed of adjustment towards the long-run equilibrium value, are negative and significantly different from zero at 5 per cent statistical level. According to Lagrange Multiplier (LM) test, there is no serial correlation in the residual. Jarque-Bera test suggests the presence of multivariate normal in the residual.

Table 4.3

Johansen Cointegration Tests

	Trace statistic (λ_{trace})			**Maximum eigenvalue statistic** $(\lambda_{\max})$		
	$r = 0$	$r \leq 1$	$r \leq 2$	$r = 0$	$r = 1$	$r = 2$
Model (*F*, *G*, *T*) with *RULE*	53.993*	16.816	5.767	37.177*	11.048	5.767
Model (*F*, *G*, *T*) without *RULE*	46.120*	12.022	4.245	34.098*	7.777	4.245

Note: * indicate 5% level of significance. The optimal lag length is found from AIC criteria to be one.

Source: Author's calculation

Table 4.4

Co-integrated Equations

Model	**Intercept**	**G**	**T**	α_{11} [1]	**LM** [2]	**Joint Jarque-Bera test statistic** [3]
(F, G,T) with *RULE*	-2.363*	0.278*	-0.229*	-0.229*	10.37	6.049
(F, G,T) without *RULE*	-8.315*	0.814*	-0.388*	-0.291*	9.86	6.673

Notes: Normalized variable is F. * is significant at 5% level.

[1] α is the loading factor which measures the speed of adjustment when there is a deviation from the long-run equilibrium.

[2] LM refers to Lagrange Multiplier test statistics for no serial correlation in the residual.

[3] Jargue-Bera test statistic is normal distribution in residual testing (The null hypothesis, Ho : residual are multivariate normal is not reject at 1% level of significance).

Source: Author's calculation

4.3.2 Causality Tests

Against the backdrop of the presence of one cointegration relationship between financial development and growth with and without *RULE*, the causality relationship based on the VECM is used to examine the null hypothesis of no causality. The causality test result with and without *RULE* are reported in Table 4.5 - 4.6

The significance of testing the lagged dynamic terms, the null hypothesis, $H_0 : all\ \theta_{1j} = 0$, by using the Wald test is to examine whether G_t causes F_t in short-run. Non-rejection of the null hypothesis implies that growth does not Granger-cause finance in short-run. To conduct the weak exogeneity test, the statistical significance of α_{11} is examined. If α_{11} is not significantly different from zero, it implies that growth does not Granger-cause finance in long-run. Conversely, $H_0 : all\ \theta_{2j} = 0$ and α_{21} are examined to test whether F_t causes G_t in short and long run. If both of hypotheses are not significantly different from zero, it implies that finance does not Granger-cause growth in short and long-run, respectively.

In panel A of table 4.5, there are two possible channels of causation, short- and long-run. The χ^2-test (column 2) and the *t*-test (columns 3) reveal both short- and long-run causality from economic growth to financial development. Both of tests are statistically significance at 5% level. They indicate that growth granger-causes finance in short- and long-run relationship. In the case of the causalities test from financial development to economic growth in panel B, both of tests are also statistically significance at 5% level. They indicate that finance granger-causes growth in short and long-run relationship.

Regarding to the model without *RULE* in panel C of table 4.6, there are two possible channels of causation, short- and long-run. The χ^2-test (column 2) and the *t*-test (columns 3) reveal both short- and long-run causality from economic growth to financial development. Only *t*-test is statistical significance at 5% level. It indicates that growth granger-causes finance only in long-run relationship. In case of the causalities test from financial development to economic growth in panel D, only χ^2-test is statistically significance at 5% level. It indicates that finance granger-causes growth only in long-run relationship.

According to table 4.7, the Granger causalities relationship between financial development *(F* without *RULE, P, A and M*) and economic growth *(G)* are tested. It indicates that there are bi-directional causality between financial development and economic growth only in long run. There is no causality relationship between financial development and economic growth in short run. So, the causality test result from those variables without *RULE* is consistent.

In sum, the econometric result supports the bi-directional relationship between financial development and growth in short and -long run. That is, financial development can promote long-term economic growth which is further creating demand for financial services. Nevertheless, policy inferences from this finding must be interpreted cautiously because of the high degree of discretion in constructing *RULE.* Besides, the study finds that if *RULE* is excluded, the bi-directional relationship turns out to be statistically insignificant in short run. All in all, these results do not completely reject the growth-enhancing effect of financial development. Instead our outcomes point to a possible adverse effect from an economic ideology that treats financial development as a prerequisite of sustainable long-term economic growth and aggressively promotes the financial sector. In fact, the financial sector development must go hand in hand with economic development.

Table 4.5

Causality Tests between Financial Development (with *RULE*) and Economic Growth

Panel A	Short run[1]	Long run[2]	Direction causality
Ho : $\Delta G \not\rightarrow \Delta F$	Granger non-causality test (Ho : all $\theta_{1j} = 0$)	Weak exogeneity test (Ho: $\alpha_{11} = 0$)	ΔED causes ΔFD in short and long-run relationship.
Model *F* = f(*G*, *T*)	0.840*	-0.229*	
Panel B	**Short run[1]**	**Long run[2]**	**Direction causality**
Ho: $\Delta F \not\rightarrow \Delta G$	Granger non-causality test (Ho : all $\theta_{2j} = 0$)	Weak exogeneity test (Ho: $\alpha_{21} = 0$)	ΔFD causes ΔED in short and long-run relationship.
Model *G* = f(*F*, *T*)	0.240*	0.214*	

Note : ΔG and ΔF are economic growth and financial development indicators respectively. * is significant at 5% level. [1] t-statistics is used to test Weak exogeneity. [2] Chi-sq (χ^2) is used to test Granger non-causality (short-run). The results are still consistent when financial development index checks sensitivity from changing weighting scores.

Table 4.6

Causality Tests between Financial Development (without *RULE*) and Economic Growth

Panel C	**Short run** [1]	**Long run** [2]	**Direction causality**
Ho : $\Delta G \nrightarrow \Delta F$	Granger non-causality test (Ho : all $\theta_{1j} = 0$)	Weak exogeneity test (Ho: $\alpha_{11} = 0$)	ΔED causes ΔFD in only long-run relationship.
Model *F* = f(*G*, *T*)	0.260	-0.291*	
Panel D	**Short run** [1]	**Long run** [2]	**Direction causality**
Ho: $\Delta F \nrightarrow \Delta G$	Granger non-causality test (Ho : all $\theta_{2j} = 0$)	Weak exogeneity test (Ho: $\alpha_{21} = 0$)	ΔFD causes ΔED in only long-run relationship.
Model *G* = f(*F*, *T*)	0.051	0.178*	

Note : ΔG and ΔF are economic growth and financial development indicators respectively. * is significant at 1% level. [1] t-statistics is used to test Weak exogeneity. [2] Chi-sq (χ^2) is used to test Granger non-causality (short-run). The results are still consistent when financial development index checkes sensitivity from changing weighting scores.

Table 4.7

Summary of Causality Results from Various Financial Development Indices

MODEL (*F, G, T*)	**Number of Lag**	**Short-run**		**Long-run**		**Normality & no serial correlation in residual**
		$\Delta FD \rightarrow \Delta ED$	$\Delta ED \rightarrow \Delta FD$	$\Delta FD \rightarrow \Delta ED$	$\Delta ED \rightarrow \Delta FD$	
Test by using *F* with *RULE*	1	YES	YES	YES	YES	YES
Test by using *F* without *RULE*	1	NO	NO	YES	YES	YES
Test by using *M*	1	NO	NO	YES	YES	YES
Test by using *P*	2	NO	NO	YES	YES	YES
Test by using *A*	1	NO	NO	YES	YES	YES