External Debt and Growth Dynamics

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EXTERNAL DEBT AND GROWTH DYNAMICS

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SINGAPORE MANAGEMENT UNIVERSITY
2006
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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ECONOMICS

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Abstract

Based on an extended growth model, this thesis further explores the joint dynamics between external debt and growth. The model explicitly expresses this growth dynamic mechanism incorporating external debt as an important explanatory variable with risk premium and other related structural factors. The interactions between external debt and growth are interpreted as directly and mainly through the channel of capital accumulation and indirectly through technology change. These constitute the functional form foundation to solve the main concern on the effect of external debt upon growth adjustment path. The numerical simulations of the model indicate that when external debt is assumed to be exogenous, the adjustment speed rises with higher risk premium or debt level. However, when external debt is assumed to be endogenous, the adjustment speed turns out to be lower with higher risk premium when external debt goes beyond a certain level. In comparison with the numerical simulations based on the extended model and specified parameter values, this study also contains a nonparametric empirical approach that focuses on the debt-growth relation in the context of the Philippine economy. Relaxing the structure functional form and assumptions, the nonparametric estimation uses the simplified form linking the change of growth rate with lagged external debt level. The results report that the effect of external debt on growth in Philippines is not very significant; while, GDP and export growth beyond some certain level are accompanied by external debt decreases. Simultaneity and omitted variables in the nonparametric model may bias these results---hence these results should be considered as initial steps in the direction for testing the real debt-growth relation.

Key words:
risk premium, adjustment speed, joint dynamics, simulation, nonparametric estimators, efficiency of external debt management
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I. Introduction

The debt crisis during the early 1980s severely affected the economic performance of many low-income developing countries and debt-relief initiatives were taken to reduce the deleterious impact of high external indebtedness\(^1\) on the growth of indebted countries. Actually, the repayment of external debt depletes already scarce capital resources, including tremendous government shares and grabs the opportunities from growth orientations such as profitable investments, export production support, human capital and infrastructure expenditures. Additionally, as the ratio of external debt to GDP increases, the marginal real cost of external borrowing (which is the sum of the risk-free interest rate and a risk premium) accordingly increases. This would lead to liquidity and solvency problems, which may even result in financial crisis. All in all, the over-surge of external debt leads to investment slowdown and reduced economic growth rate. In relation to this, the notions of “debt overhang” and “debt laffer curve” introduced in later literature review part are thus helpful in understanding the negative impacts of high debt burden on investment incentive and production to justify debt relief.

However, with other conditional variables constant, the borrowing resource (external debt) as one of the main supplements that fill the financing gap\(^2\) should yield at least an interim period development for many developing countries, which are plagued by the lack of domestic savings and high current account deficits. The effect of external debt on growth may also be resulted from the efficiency of external debt management, whether the debt funds are channeled into growth promotion orientations with effective usages that can make the positive effect of debt on growth more than the negative effect.

If the policy makers of indebted countries study the adjustment speeds of GDP growth rate in order to reach some intended long-term equilibrium steady state, they would learn about the dynamic mechanisms involved in the external debt-growth interactions. This thesis uses the extended growth model to give the complicated

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\(^1\) In this thesis, “external debt” refers to a country’s total external debt that includes the stock of debt owed to nonresident governments, businesses and institutions and repayable in foreign currency, goods or services. According to World Bank (1993) and used in the entire thesis, external debt includes public and publicly guaranteed debt, as well as private debt.

\(^2\) Financing Gap is normally defined as the gap between intended investment and domestic available resources based on the Harrod-Domar model (1946).
interactions a summary and to elaborate and quantify them. Furthermore, to provide policymakers with some reference to handle the debt and related issues to better facilitate growth, assessments are made on the growth sustainability of different external debt levels. Then initiatives can be taken to control the debt and subsequently facilitate the growth to reach ideal adjustment speeds. At the same time, a proper degree of debt-relief measures (sometimes from IMF or World Bank) will ensure that the debt burden does not hamper capital formation and growth.

The purpose of this thesis is not to elaborate on any external debt liquidity, solvency or debt crisis related issues. The core concern is about the growth path of indebted developing countries, in particular, how external debt affects growth. The study uses the extended growth model of Mariano and Villanueva (2005) as the theoretical base for the research. The MV model refines the standard neoclassical growth model in a closed economy to incorporate global capital markets and to endogenize technical change through the assumption of learning by doing. Mainly through capital accumulation, also indirectly through technological change and other mutual factors like depreciation and savings rates, the model then exhibits the joint dynamics of external debt and growth.

The main results of this study are to quantify the adjustment speed of developing countries towards steady state growth rates. More specifically, in Chapters IV & V of this study, the MV model is simulated utilizing representative parameter values of the Philippine economy to analyze the effect of external debt on adjustment speeds towards equilibrium growth rates. Two sets of simulations are performed—the first set assumes external debt to be exogenous; the second set assumes external debt to be endogenous in the model. The numerical simulations of the model indicate that when external debt is assumed to be exogenous, the adjustment speed rises with higher risk premium or debt level. However, when external debt is assumed to be endogenous, the adjustment speed turns out to be lower with higher risk premium when external debt goes beyond a certain level.

In chapter VI, this thesis carries out a nonparametric empirical approach to further explore the debt-growth relation in the context of the Philippine economy. The results of this approach serve as a comparison with the simulation part. There are major differences

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3 Later, we refer to the extended growth model of Mariano and Villanueva (2005) as “MV model”.

5
in the two approaches. First, the nonparametric method relaxes the important assumption that external debt funds are directed into development channels and that debt-management is efficient ----- thus allowing for the possibility of misuse of the external debt fund or low efficiency of external debt management. Second, the functional form of MV model which gives specific elaboration on the mechanism of external debt-growth relation is simplified in the nonparametric approach-----to emphasize the debt effect, excluding other variables and parameters. The sample consists of quarterly data from Philippines from February 1993 to November 2004. The results may give us some insight into external debt and growth relation in sample period of Philippines economy: external debt may not have some significant effect on growth without certain assumed conditions. Also, more significantly, we can see in our empirical results that, upon some certain level, higher GDP or export growth rate will decrease the external debt level. The results must be taken with caution because the nonparametric regression has its main disadvantage of missing some other potentially important factors, plus limitation on scope of the sample period. So the empirical test reported in this study is a tentative first step in analyzing further the relation between external debt and growth.
II. Literature Survey

Growth and Convergence

The Harrod-Domar model (1946) serves as a luminary work in this study for its analysis of growth. Assuming full employment, market clearance, and perfect competition, this model attempts to show that economic growth is based directly on capital accumulation. According to this model, if debt can raise capital accumulation, growth will be achieved. In relation to this, Arthur Lewis (1954) stated

“The central problem in the theory of economic development is to understand the process by which a community which was previously saving and investing 4 or 5 per cent of its national income or less, converts itself into an economy where voluntary saving is running at about 12 to 15 per cent of national income or more. This is the central problem because the central fact of economic development is rapid capital accumulation (including knowledge and skills with capital).”

Based on this statement, increasing domestic savings rates would ensure growth because the capital accumulation is at the center of development. On the other side, it is shortage of capital, not of labor or technology, which prevents industrial growth. However, empirical evidence in developing countries since the 1960s does not support theories similar to this since massive external debt accumulated is not accompanied by an increase in per capita income.

The Neoclassical Growth model by Solow-Swan (1956) identifies two possible variation sources of output per worker: differences in capital per worker and differences in the effectiveness of labor, with a very important assumption that technical change and saving are exogenous and the technology process is labor-augmenting or Harrod-neutral. The principal conclusion of Solow model is that there will be an effect on the income level of savings but the accumulation of physical capital cannot account for either the vast growth over time or the vast geographic differences in output per person, thus the

4 If knowledge or effectiveness of labor $A$ enters in the output growth with form $Y = F(K, AL)$, this technology progress is Harrod-neutral. In this study, $Y$ represents output, $K$ means capital and $L$ is labor.
long term driving force of growth is the exogenous technology change or the effectiveness of labor. This position also rests on certain points: (a) fundamental forces like resources, preferences, and technology lead to Pareto-efficient outcomes, and (b) institutions do not even influence the choice of the equilibrium. Representing the technical change function in the reduced growth models of Mariano and Villanueva (2005), external debt affects the technology change indirectly through capital accumulation. In this way, external debt should also have growth effects in the long run. However, the abovementioned models have not identified the exact meaning of “technology” or “the effectiveness of labor”; and more, what causes its change. One catchall factor corresponding to this is abstract knowledge, so the determinants of stock of knowledge will impact growth finally, and cross country difference. The possible determinants beyond the most direct understanding of technology include education level and skill qualifications of the labor force, strength of property rights, quality of infrastructure, cultural attitudes towards work, entrepreneurship and teamwork spirit during work, managerial ability level, and so on.

Conlisk (1967) modified neoclassical growth model to make the technical change endogenous within a closed-economy model. The asymptotic equilibrium growth rate of the modified model is found to be positively related to the value of saving rate; while the former neoclassical growth models emphasize that the equilibrium growth rate is not affected by the saving rate in long run. Another difference is the equilibrium growth rate also depends on other parameters besides working population growth rate like elasticity of output. The reduced MV model is after further steps based on Conlisk (1967): their main development is extension from closed-economy into open-economy with influence of global capital market.

Conlisk gives a rough empirical test using cross-country growth data to that prove data favors the modified over the former standard model.

Related to our method to simulate the speed of adjustment of the change of output growth rate toward its long term equilibrium, Conlisk (1966) also did the pioneer work to incorporate Keynesian unemployment, as the affecting factor(similar to our external debt), into neoclassical growth model to examine proportionate growth adjustment time. His extended model is obtained by grafting a few Keynesian relations on to a standard growth
model. While the model in its simplest form may yield relevant limiting results, a more inclusive model seems needed to get at the details of the adjustment to the limit. More specifically, it has been shown that extending the simplest model to include the possibility of unemployment reduces adjustment times compared to their estimated former values. But he admits that since this extended model is still highly simplified, these conclusions are quite tentative.

Later on, the focus of theories moves on. Specifically, Lucas (1988) accounts growth across countries and across time by using levels and rates of growth in per capital income, which he believes integrating many aspects and features of growth. He contends that a successful theory of economic development clearly needs, in the first place, to be consistent with sustained growth and diversity of income levels. He develops the mechanics modeling closely on neoclassical model of Solow and Denison and fit for the features of wide diversity in sustained growth of per capita incomes at all income levels. With its extreme assumption that assigns no importance to differences in endowments of natural resources and that permits perfectly free trade in capital and consumption goods, his theory is a system with a given rate of population growth but which is acted on by no other outside or exogenous forces. In his system, there are two kinds of capital, or state variables, namely, physical capital that is accumulated and utilized in production under a familiar neoclassical technology, and human capital that enhances the productivity or both labor and physical capital, and that is accumulated according to a 'law' having the crucial property that a constant level of effort produces a constant growth rate of the stock, and independent of the level already attained. His system is different with others in that the marginal productivity of physical capital tends to a constant asymptotically, which is implied by the long-run relationship between the two kinds of capital that holds in each country no matter what the level of capital has been accumulated. Lucas also points out that comparative advantages that dictate a country's initial production mix will simply be intensified over time by human capital accumulation, but he conjectures that a more satisfactory treatment of product-specific learning should involve modeling the continuous introduction of new goods, with learning potentials on any particular good declining with the amount produced.
The debates between Solow’s Exogenous Growth Theory and Romer’s Endogenous Growth Theory represent the controversy in the huge field of research on convergence. According to the Solow models, one can derive both absolute and relative convergence. Absolute convergence implies that the rate of return on capital is lower in countries with more capital per worker. Thus there are incentives for capital to flow from rich to poor countries. Relative convergence results from the differences in the technology and saving rates of various countries. With the assumption that the labor-augmenting technical change is exogenous, Solow’s model emphasizes the capital accumulation as the source of conditional convergence, whereas Romer (1986) and Lucas (1988) deem a combination of physical and human capital as the principal engine of growth. Romer models make a difference in technology change across countries and overtime as the source of convergence. From Romer and Barro (1992), convergence is also conditional on the different structural characteristics of economy, such as its social preferences, technologies, rate of population and government policy. Different structural characteristics imply different steady-state relative per capita incomes. Beginning with Baumol (1986), these theories have been subjected to extensive empirical testing. Much of the theoretical and empirical literature is summarized in Sala-i-Martin (1995), Quah (1996) and Jones (1997).

Kumar and Russell (2002) construct the measurements for the world production frontier and relative country’s efficiency level to give the static comparison of economies growth states. Their empirical search find the world growth represented by productivity distributions in period 1960-1990 change from uni-modal into bimodal showing bipolarization character. By building-up models for tripartite decomposition of convergence, they suggest three components of productivity change: technological efficiency change shifting the world production frontier, its catch-up movements towards or away from the frontier and capital accumulation. Their systematical empirical demonstrations and analysis on the Kernel distribution results gives separate effects on growth dynamic pattern, that worldwide technology frontier is moving up with substantial evidence of technology catch-up, but the technological change is decidedly not neutral, benefiting the richer countries more than the poor. They conclude that technology catch-up not seems to be a strong force and technology efficiency change do
somewhat more than technology catch-up but not much, capital accumulation contributed
the most to both the growth and bipolar international divergence.

Neoclassical theorists could not refute the fact that the kind of convergence
predicted by their theory is not occurring. When neoclassical economists go beyond the
fundamentals of resources, technology, and preferences, they focus almost exclusively on
government. They argue that government performance become impediments to prevent
markets from working smoothly. Departing from the strong assumptions of neoclassical
theory and different to Romer’s Endogenous Growth theory, Hoff and Stiglitz (2000)
argue that the fundamentals in neoclassical theory are not the only deep determinants of
economic outcomes. They focus on four: institutions, the distribution of wealth, history,
and “ecology”—which mean the behaviors of other agents rather than the government in
the economy that have spillover effects. They emphasize that information and
enforcement problems impose limits on economic possibilities that are just as real as the
limits of technology. Non-market institutions arise in response to those limits and
influence outcomes. They contend that wealth distribution affects contracts, incentives,
and outcome while history influences a society’s technology, skill base, and institutions.
It is not necessarily true that the impact of past events erodes over time. At the same time,
they summarize that “Ecological economics,” more generally, modern development
economics rejects the very notion of “equilibrium” that underlies in traditional theories.
In contrast, they tend to be influenced more by biological than by physical models. The
latter emphasize the forces pulling toward equilibrium—and with similar forces working
in all economies, all should be pulled toward the same equilibrium—while the latter
focus more on evolutionary processes, complex systems, and chance events that may
cause systems to diverge.

In this case, economy is like an ecosystem, and Darwin implicitly recognized that
ecosystems have multiple equilibria. In contrast with traditional theories, the endogenous
variables are far more important in determining the evolution of the system than the
fundamentals. Luck or accidents of history may play a role in determining that
environment in the selection of the equilibrium. Under the older theory, “all” one had to
do to ensure development was to develop technology, increase capital accumulation and
remove government-imposed distortions. But the new theories suggest, “all” one has to
do is to induce a movement out of the old equilibrium, sufficiently far and in the right direction, so that the economy will be “attracted” to a new, superior equilibrium.

The convergence in our analysis is expressed as the different adjustment speeds towards the long run equilibrium with different assumptions on external debt. The faster the adjustment speeds, the more hope developing countries could catch up, or become closer to the growth level of developed ones. Nonetheless, based on endogenous growth model incorporating technology and capital in global market, similar to the above modern development economics, we emphasize the decisive role of government in the realization of the effect of external debt on growth. Only under the strong assumption that government has properly channeled the external debt funds into growth orientation directions with effective usages, expected growth adjustment speed can be reached. By contrast, loose the crucial assumption in real data situation, if the tests not support the strong positive relation of external debt to growth, that may imply that mismanagement of external debt exist.

**The Effects of Debt Overhang on Growth**

The situation when the contractual value of debt is less than the expected repayment on external debt is defined by Krugman (1988) as “debt overhang”. This theory focuses on the adverse effects of external debt on investment in physical capital. First, when external debt reaches a high level, investors lower their expectations on investment returns with the possibility of progressively more distorted taxes by the government for debt repayment. In this way, high debt discourages domestic and foreign investment incentive and also slows down physical capital accumulation. With a broader scope based on this theory: as any fiscal reform including some indirect effects through structural reforms, could strengthen the pressures of repayment to foreign creditors, so a certain high level of external debt can also reduce a government’s incentive to carry out fiscal reforms. But the acceleration of structural reforms are especially needed by the indebted developing countries to sustain higher growth to meet the MDGs. So the disincentives for reform should be paid with special concern by these countries.
With the debt-overhang hypothesis, Sachs (1989) has given an explanation for the debt crisis puzzle. Expected debt service volume would be an increasing function of the country’s output level, if there is some probability that debt level is expected to exceed the country’s repayment ability. As foreign creditors “tax away” part of the returns from domestic investments, local economic growth is discouraged. In Oks and Wijnbergen (1995), if the private sector fears imminent devaluation or increases in taxes to service the rapid accumulation of debt, it is possible to have an increase in capital flight. Agénor and Montiel (1996) discussed increasing uncertainty caused by the debt overhang to depress investment and growth. There may be expectations that the government will use some distorted measures to fulfill debt obligations when the stock of public sector debt increases. In Serven (1997), potential private investors prefer to wait for the change of circumstances. Moreover, the investment is more likely to be directed into channels with quick returns rather than into long-run beneficial ones.

Pattillo (2004) and many others argued that high debt levels may also constrain growth by lowering total factor productivity growth. One reason is if the government perceives that the benefit of higher output will partly accrue to foreign creditor, their promotion to reform and upgrade their productivity will be lower. At the same time, the debt-overhang brings uncertainties and instabilities, letting investments be misallocated to short term projects rather than long term ones, thus resulting in high risk of irreversible investment which may be conducive to productivity growth. Thus debt-overhang hinders the productivity growth both with low incentive for improvement and resource misallocation. In the reduced models on which our analysis is based, external debt which affects technology growth indirectly through capital accumulation, can partly explain these links.

Using probit regressions, Kraay and Nehru (2003) empirically examine the determinants of ‘debt distress”, which they define as periods in which countries resort to exceptional finance like significant arrears on external debt, Paris Club rescheduling or non-concessional IMF lending. They find that the debt burden, the quality of policies and institutions, and shocks explain a substantial fraction of the cross-country and time-series variation in the incidence of debt distress. When country receives a substantial fraction of new lending, increasing its present value of debt from 1.7 times exports to nearly 3 times
exports, given other policy and growth constant, this would increase the predicted probability of debt distress from 13 percent to 21 percent.

Bordo and Meissner (2005) describe the role of foreign currency debt in precipitating financial crises by comparing the 1880 to 1913 period to recent experience. Paying special attention to the role of hard currency debt and debt intolerance, they examine debt crises, currency crises, banking crises and the interrelation between these varieties of crises. They find fairly robust evidence that high exposure to external debt does not necessarily lead to a high chance of having a debt crisis, currency crisis, or a banking crisis. A key finding is some countries do not suffer from great financial fragility despite high exposure to original sin. A strong reserve position or high exports relative to hard currency liabilities helps decrease the likelihood of a debt crisis. But they strengthen the evidence for the hypothesis that external debt is dangerous when mismanaged based on discussion on the robustness of these results and make some general comparisons from over 60 years of intense international capital market integration. These results are partly confirmed with our empirical test, that though we haven’t find any evidence of such highly negative effect, at least debt mismanagement would lead the external debt has no significant positive effect on indebted developing countries’ growth.

Cordella and Ricci (2005) look at how the happening of debt overhang effect varies with indebtedness levels and other country characteristics in a panel of Highly Indebted Poor Countries. Their findings suggest that there is a negative marginal relationship between debt and growth at intermediate levels of debt, but not at very low debt levels, below the “debt overhang” threshold, or at very high levels, above the “debt irrelevance” threshold. Countries with good policies and institutions face overhang when debt rises above 15-30 percent of GDP, but the marginal effect of debt on growth becomes irrelevant above 70-80 percent. In countries with bad policies and institutions, overhang and irrelevance thresholds seem to be lower with their result, but they cannot rule out the possibility that debt does not matter at all.
Cohen (1993) expressed the relationship between the face value of debt and investment as a kind of “Laffer curve” such that foreign borrowing has a positive impact on investment and growth up to a certain level; beyond this level, however, its impact is adverse. As evidence in support of the debt overhang hypothesis, Greene and Villanueva (1991) found that there is significantly negative effect of external debt to GDP ratio to the rate of private investment based on time-series data from 23 developing countries from 1975-1987. Elbadawi and others (1997) with a dynamic panel model to examine the nonlinear effects of external debt to growth reported the Laffer curve effect on debt to GDP ratio of 97 percent. From his correlation of growth and external debt to explain the growth performance of developing countries, Cohen (1998) examined the relationship between growth and external debt of Latin American and African countries to explain their poor growth. Cohen concluded closed economies do not risk much by threatening to default, but, along with exchange rate mismanagement, external debt mismanagement does hurt countries that are open to trade. From his correlation of growth and external debt, Cohen also constructed new solvency indicators. Besides the two external debt benchmarks set by World Bank: a debt-to-export ratio above 220 percent; and a debt-to-GDP ratio above 80 percent, he argued that a debt-to-tax ratio is also very effective to predict debt crisis. Similar to our conclusions arising, the one who hurts the indebted economy body is not external debt itself, but the mismanagement of external debt which largely depends on how the governmental policy makers handle the usage issue of external debt fund, whether they make it benefit the development or oppositely misuse it, thus even creating crisis. Cohen also constructed three corresponding debt thresholds above which the risk of debt crisis appears to have the largest negative effect on growth: debt-to-export above 200 percent; debt-to-GDP above 50 percent; and debt-to-tax above 300 percent. Estimated by Clements and Bhattacharya (2003), the threshold level is to be around 50 percent of GDP for the face value of external debt, and 20–25 percent of GDP for its estimated net present value. Recent studies find strong support for a nonlinear, Laffer-type relationship between the stock of external debt and growth.
Surveying a large panel data of 93 developing countries over the period 1969–1998, Pattillo and others (2002) found the average impact of external debt on per capita GDP growth to be negative for net present value of debt levels above 160-170 percent of exports and 35–40 percent of GDP. These results remain robust across different estimation methodologies and specifications, and suggest that doubling debt levels slows down annual per capita growth by about half to a full percentage point. Debt also appears to affect growth via its effect on the efficiency of resource use, more than that of its depressing effect on private investment. For countries with average indebtedness, they suggested that doubling the debt ratio would reduce annual per capita growth by between half and a full percentage point, while for countries under the heavily indebted poor country initiative, reducing the debt ratio by half would increase annual per capita growth by 1 percent, unless constrained by other macroeconomic distortions.

Pattillo and others (2004) tested the nonlinear effects of debt on growth and whether the effects happen mainly through factor accumulation and factor productivity growth. With a panel dataset of 61 developing countries like Sub-Saharan Africa, Latin America and the Middle East over the period 1969-1998, their augments used a standard growth specification based on conditional convergence by adding several debt indicators and assuming a constant returns to the scale production function. To estimate with the models for the different components of growth, they used the estimators including traditional Ordinary Least Squares, instrumental variables and the more recently differenced Generalized Method of Moments. They controlled the biases generated with unobserved country-specific effects and the endogeneity by using an optimal instrument set based on lagged values of potentially endogenous variables, which is similar to the method we use in this paper to get rid of endogeneity. To check the robustness of their results, they employed identification through heteroskedasticity. They found that doubling debt will reduce output growth by 1 percent, within which approximately one-third of the effect occurs via physical capital accumulation and two-thirds via total factor productivity growth. Specifically, both quadratic and spline (inverted V) function approaches were employed by them to examine the structural break of the debt’s impact on growth. By varying the threshold and evaluating which regression produced the highest R-squared, they yielded turning points of 65 percent for debt to exports and 18
percent for debt to GDP beyond which the impact of debt on growth turned from positive to negative.

Clements (2003) finds results to suggest that the substantial reduction in the stock of external debt projected for highly indebted poor countries would directly increase per capita income growth by about 1 percentage point per annum. Reductions in external debt service could also provide an indirect boost to growth through their effects on public investment. If half of all debt-service relief were channeled for such purposes without increasing the budget deficit, then growth could accelerate in some HIPCs by an additional 0.5 percentage point per annum.

From the opposite direction, Easterly (2001) pointed out the effect of growth slowdown on external debt level. When countries failed to adjust to the negative fiscal consequences of the growth implosion, present value of tax revenues and primary surpluses were much lower, and public debt to GDP ratios exploded. The growth slowdown therefore played an important role in the debt crisis of the middle income countries in the 1980s, particularly the crisis of the Highly Indebted Poor Countries (HIPCs) in the 1980s and 1990s.

Furthermore, Easterly (2003) emphasized the importance of foreign aid management, macroeconomic policy and political environment in the realization of aid purpose. With institutional and policy distortions, foreign aid may not positively correlate with intended growth. As Burnside and Dollar (2000) mentioned, “We find that aid has a positive impact on growth in developing countries with good fiscal, monetary, and trade policies but has little effect in the presence of poor policies.” This point may be one explanation for our empirical test on the real economic situation of the Philippines to understand the significance of the effect of external debt on growth. We emphasize the importance of foreign aid management, macroeconomic policy and political environment in the realization of aid purpose.

Further Easterly (2004) criticizes research on foreign aid effectiveness and growth frequently "becomes a political football". He finds that “aid buys growth” is on shaky ground theoretically and empirically. It doesn’t help that aid agencies face poor incentives to deliver results and under invest in enforcing aid conditions and performing scientific evaluations. Different with others he suggests the appropriate goal of foreign
Easterly (2002) explains the reason why aids can’t give ideal results by the existence of group of national and international bureaucracies dispensing foreign aid. He finds the aid bureaucracies led those organizations to first, define their output as money disbursed rather than service delivered, second, produce many low-return observable outputs like glossy reports and “frameworks” and few high-return less observable activities like ex-post evaluation, third engage in obfuscation, spin control, and amnesia so that there is little learning from the past.

Our paper also agree with his idea that the international aid could gradually evolve into more effective and more accountable agencies, much as national governments in the now-rich countries gradually evolving from venal scoundrels to somewhat more effective and accountable civil servants, at the same time, reduce the debt bureaucracies to as far extent as possible. In any case, improving quality of aid should become before increasing quantity, which is difficult but not impossible.

**Related Work**

Belonging to the class of “endogenous growth” models with the abovementioned Romer (1986), Lucas (1988), Grossman and Helpman (1990), Villanueva (1994) incorporated the effect of learning through experience on the steady-state growth rate of output. The model is a variant of Conlisk’s (1967) endogenous-technical change growth model and Arrow’s (1962) “learning by doing” model. The key relationships postulated by the models are that technical change improves with the capital stock per capita and learning experience plays a critical role in raising labor productivity over time. The presence of learning experience makes the growth equilibrium endogenous. Contrary to the conclusion of Solow-Swan model, in this model, growth equilibrium cannot only be influenced systematically by the changes of private rates of saving, depreciation and
population growth. Furthermore, it can also be positively affected by policies regarding trade openness (the ratio of foreign trade to GDP), fiscal deficits, expenditures on human resource development and net investment through learning coefficient. In this way, Villanueva’s (1994) work expands Conlisk’s (1967) model to incorporate learning, and changes the statue of economy from closed to open.

A very important contribution of Villanueva (1994) adopted by this paper is the simulation method of the adjustment speed toward equilibrium, which transforms the specific functional form of production to express the time path and use representative values of structural parameters to calculate the estimates of adjustment time needed to reach growth levels proportionate to the steady-state growth rate. The results here reveal that the adjustment times in the endogenous growth model are generally a quarter to a third of those in the exogenous one. In addition, through the enhancement of learning coefficient, the policies related to the extend of openness, the depth of human development and the quality of fiscal management can further reduce the adjustment time and reach the equilibrium faster. Accordingly, in our paper, the adjustment speeds are compared with different risk premium levels representing different burden levels shouldered by the economy during the process of pursuing equilibrium growth rate.

Based on the existent endogenous growth model but on a higher layer, Mariano and Villanueva (2005) incorporated external debt as an added factor to explain indebted countries’ growth and extend the horizon from Solow’s close economy to open for global capital market. Upon strict assumptions, their model gives direct expression of the joint interaction dynamics of external debt, capital accumulation and growth: the steady-state ratio of external debt to GDP is constant at the output growth equilibrium level when the expected net marginal product of capital matches the marginal cost of funds. Although constant in the long-run, the steady-state external debt ratio is diversified with differences in the economy’s propensity to save, marginal cost of funds, depreciation rate, working population growth rates and other exogenous parameters like risk-premium. However, in general, the existence, uniqueness, and stability of the steady state equilibrium are not guaranteed. Moreover, their work demonstrates that with the linear ‘learning-by-doing’ and risk-premium functions and values of the parameters for the Philippines for a Cobb-
Douglas production function, the extended model’s equilibrium is locally stable in the neighborhood of the steady state.

Another significance of the model is that one is to estimate the optimal domestic saving rate which maximizes the real consumption per unit of effective labor in the long run as consumption is taken as welfare indication and also the reduced models give long run steady states’ expressions of external debt. Their model also reports the threshold in the range of 38-52 percent of GDP for the Philippines, after which the impact of external debt to growth turns from positive to negative. They give the policy implication that when risk spreads are highly and positively correlated with rising external debt levels, unabated foreign borrowing depresses long run welfare. Another significant point the paper makes is that the estimation for the steady-state ratio of net external debt to GDP is associated with the optimal outcome in the long run. These results, together with their basic and reduced models, are taken as our research starting point and theoretical base for this paper.
III. Basic and Extended Models

In this section, we discuss the extended model developed by Mariano and Villanueva (2005). The relative simplicity of the model makes them a convenient framework to illustrate the joint dynamics of external debt, capital accumulation, and growth. The following assumptions are required for their analysis; first, for the debt ratio to stabilize, if the expected net marginal product of capital exceeds the effective real interest rate in global capital markets, debt accumulation can go beyond the economy’s steady-state growth rate. Second, the marginal real cost of external borrowing is set as the sum of the risk-free interest rate and a risk premium. The risk premium is defined as an increasing function of the ratio of external debt to capital stock and inter alia, with the risk-free interest rate unchanged. Third, the change of external debt-capital ratio is determined by the difference between the expected marginal product of capital, net of depreciation, and the marginal cost of funds in the global capital market. Fourth, the aggregate capital stock is the accumulated sum of domestic saving and net external borrowing or the current account deficit.

\[ Y = Lk^\alpha \quad \text{(Real GDP),} \quad 0 < \alpha < 1 \]  
\[ \text{GNDI} = Y - \text{NFP} + \text{NTR} \quad \text{(Gross National Disposable Income)} \]  
\[ \text{CAD} = S^f = C + I - \text{GNDI} \quad \text{(Current Account Deficit)} \]  
\[ C = c \text{GNDI} \quad \text{(Consumption function)} \]  
\[ \text{NFP} = rD \quad \text{(Net factor payments)} \]  
\[ \text{NTR} = rY \quad \text{(Net transfers)} \]  
\[ \dot{D} = \text{CAD} \quad \text{(Net debt issue)} \]  
\[ d = D/Y \quad \text{(Debt-GDP ratio)} \]  
\[ \dot{d} / d = \alpha k^{\alpha - 1} - \delta - r \quad \text{(External Borrowing Function)} \]  
\[ r^e = r^f + \varphi d \quad \text{(Effective Interest Rate)} \]  
\[ \dot{K} = I - \delta K \quad \text{(Capital growth)} \]  
\[ L = AN \quad \text{(Effective labor)} \]  
\[ \dot{N} = nN \quad \text{(Working population growth)} \]
\[ \dot{A} = \theta(K / N) + \lambda A \] (Technical change function) (14)

\[ k = \frac{K}{L} \] (Capital-effective labor ratio) (15)

\[ r = r' + \varphi[d + \phi k^{\alpha-1}] \] (16)

\[ \frac{\dot{k}}{k} = s \left[ (1 + \tau)k^{\alpha-1} - rd \right] / (1 - d) + \left( \alpha k^{\alpha-1} - \delta - r \right) d / (1 - d) - \delta / (1 - d) - \theta k - n - \lambda \]

\[ = H(k, d) \] (17)

\[ \frac{\dot{d}}{d} = \alpha k^{\alpha-1} - \delta - r = J(k, d) \] (18)

where the variables are defined as

- $Y$ = real GDP,
- $K$ = physical capital stock,
- $L$ = effective labor,
- $A$ = labor-augmenting technology (index number),
- $N$ = working population,
- $k$ = capital-effective labor ratio,
- GNDI = gross national disposable income,
- NFP = net factor payments,
- NTR = net transfers,
- CAD = external current account deficit,
- $S'$ = saving by non-residents,
- $C$ = aggregate consumption
- $I$ = gross domestic investment,
- $D$ = net external debt,
- $d$ = net external debt/capital ratio,
- $r$ = marginal real cost of net external borrowing,
- $r^e$ = effective world interest rate,
- $r^f$ = risk-free interest rate,

As employed by Villanueva (1994), $\theta$ is the learning coefficient and $\tau$, $\delta$, $\varphi$, $n$, $\lambda$, and $\alpha$ are the positive constants. The transfers/grants parameter $\tau$ may be allowed to vary positively with the domestic savings efforts and $\tau$ is also positively related to human
capital enhancing expenditures like education, which are meant to increase learning coefficient $\theta$. In a closed economy with $D = 0$, $S^t = 0$ and with technical change partly endogenous ($\theta > 0$), the model is reduced to the Villanueva (1994) model. Additionally, if technical change is completely exogenous ($\theta = 0$), the model is reduced to the standard Neoclassical (Solow-Swan) model.

From the two key models reduced, namely equations (17) and (18), we see the interactive relation between capital accumulation (and growth with $\dot{Y}/Y = y = \alpha k/k + y_\infty$ Here, $y_\infty$ is the long term equilibrium value of production) and external debt, which is the Basis of our historical analysis. By setting the reduced model (17) and (18) to zero, we can get the steady-state solutions for $k^*$, $d^*$ and $r^*$ through

$$s[(1+\tau)k^*_{\alpha-1} - r^*d^*] / (1 - d^*) - \delta / (1 - d^*) - \theta k^* - n - \lambda = 0,$$
$$d^* = [\alpha - \phi \epsilon] k^*_{\alpha-1} - \delta - r^* / \phi,$$
$$r^* = r^* + \phi d^* + \phi \epsilon k^*_{\alpha-1}.$$

From these extended models, we can see the channels through which the external debt affects growth and vice versa. As an element in function (17) of capital growth rate, external debt directly affects growth through the nonlinear relation with capital accumulation. At the same time, in equation (16), external debt has a positively linear relationship with interest rate; the higher the external debt, the higher the interest rate. Indirectly, through capital accumulation, external debt also affects technology change and long-term effect on growth. The proportionate change in debt level is determined by the difference between the expected marginal product of capital, net of depreciation, and the marginal real cost of funds in the international capital market. From this angle, if some negative fiscal shocks lower the marginal products of capital, primary surpluses would decrease and make a given level of debt more burdensome. If there is no return-cost, the debt ratio stabilizes at a constant level when net external debt grows at the steady growth of GDP. The steady-state ratio of the stock of external debt to GDP is derived as a function of the parameters of the production function, the country’s propensity to save out of gross national disposable income, real world interest rate and risk spread. Thus it’s affected by the responsiveness of risk spread to the external debt volume and the financial market through country risk. Some countries fail to adjust the negative fiscal
consequences of the growth implosion, the public debt to GDP ratios explode with detrimental consequences. The growth slowdown therefore plays an important role in the debt crisis.

IV. Simulation of Adjustment Speed

-----When External Debt Is Exogenous

Key Assumptions

In the first part of the simulation, we assume external debt which includes total public and private debts to be totally exogenous. Thus external debt can be determined by governmental policy and is independent of k, without the existence of equation (18). Another important assumption that can be made is that external debt is assumed to be properly directed into growth orientations like investment and expenditure in infrastructure and human capital to enhance productivity. The uses of external debt as abovementioned are also assumed to be effective.

Simulation Process

In the following discussion we multiply both sides by k based on the extended model (17), and we get

\[
\frac{dk}{dt} = s\left[(1+\tau)k^{a} - rdk\right]/(1-d) + \left[(\alpha k^{\alpha-1}\delta - r\right)dk/(1-d)] - \delta/(1-d)k - \theta k^{2} - nk - \lambda k
\]  

(19)

When we incorporate equation (16) into (19), we have

\[
\frac{dk}{dt} = s\left[(1+\tau)k^{a} - \left(r k + \phi dk + \phi\epsilon k\right)\right]/(1-d) + \left[(\alpha k^{\alpha-1}\delta - \left(r k + \phi dk + \phi\epsilon k\right)\right]d/(1-d)] - \delta/(1-d)k - \theta k^{2} - nk - \lambda k = G(k)
\]  

(20)

Since the differential equation is a nonlinear function, its solution is complicated. Thus we use the linear approximation in the neighborhood of the steady-state constant value k*:

\[
\frac{dk}{dt} = G(k^*) + G'(k^*)(k-k^*)
\]

since G(k^*) = 0,

\[
\frac{dk}{dt} = G'(k^*)(k-k^*)
\]  

(21)
\[
G'(k^*) = \{s[\alpha(1+\tau)k^{\alpha-1} - (r + \varphi d + \alpha\varphi e^{k^{\alpha-1}})]d/(1-d)\} + \\
\left\{[\alpha^2 k^{\alpha-1} - \delta - (r + \varphi d + \alpha\varphi e^{k^{\alpha-1}})]d/(1-d)\right\} - 2\theta k^* [\delta/(1-d)] - n\lambda
\]  

We separate the “separable variables” form of equation (21) as the following

\[
[1/(k-k^*)]dk = G'(k^*)dt
\]

Integrating both sides,

\[
\int [1/(k-k^*)]dk = G'(k^*)t + \text{constant}
\]

\[
\log(k-k^*) = G'(k^*)t + \text{constant}
\]

\[
k = k^* + Ce^{G'(k^*)t}, \text{ where } C \text{ is a constant of integration}
\]  

(23)

With equation (21) and (23), we have

\[
k = k^* + Ce^{G'(k^*)t}
\]

(24)

From equation (1), we have

\[
Y/L = k^\alpha
\]

\[
\dot{Y}/Y = \alpha \cdot k + y_\infty, \text{ where } y_\infty = \alpha k^* + n + \lambda
\]  

(25)

Substituting equation (24) into (25), we have

\[
y_t = \alpha G'(k^*)\{1-[k^*/(k^* + Ce^{G'(k^*)t})]\} + y_\infty
\]  

(26)

Setting \(y_t = y_0\) and \(t = 0\) in equation (26),

\[
y_0 = \alpha G'(k^*)\{1-[k^*/(k^* + C)]\} + y_\infty
\]  

(27)

From equation (27), we can solve the constant \(C\) as

\[
C = k^*(y_0 - y_\infty) / [y_\infty - y_0 + \alpha G'(k^*)]
\]  

(28)

Substituting equation (28) into equation (26),

\[
y_t = \alpha G'(k^*)\{1-[k^*/\{k^* + k^*(y_t - y_\infty) / [y_\infty - y_0 + \alpha G'(k^*)] e^{G'(k^*)t}\}]\} + y_\infty
\]  

(29)

Next, we define the adjustment ratio \(p_t\) as

\[
P_t = (y_t - y_0) / (y_\infty - y_0)
\]  

(30)

To solve for the time \(t\) (in years) requires getting a fraction \(p_t\) of the way from initial \(y_0\) to intend \(y_t\), representing the adjustment speed of growth dynamic. Substituting equation (29) into equation (30), we solve

\[
t = [1/G'(k^*)] \ln\{(1 - p_t) \left[ y_\infty - y_0 + \alpha G'(k^*) \right] / \left[ (1 - p_t)(y_\infty - y_0) + \alpha G'(k^*) \right] \}
\]  

(31)

The work of Mariano and Villanueva (2005) obtained a unique optimal value for \(s\): \(s = 0.3429\) based on the interaction between \(s\) and \(k\). Meanwhile, \(d\) maximizes long-run consumption per unit of effective labor. \(\varphi = \text{Spread of External Debt/GDP}\), we have different levels of external debt/GDP ratio given different \(\varphi\) values to examine different adjustment speed of growth dynamic. An illustrative numerical example is presented.
below, using parameter values for the Philippines: $\alpha = 0.4$, $\delta = 0.04$, $\tau = 0.07$, $n = 0.025$, $\lambda = 0.02$, $r = 0.03$, $\varepsilon = 0.214$ and $\theta = 0.005^5$. Putting in place the Golden Rule condition of the standard theorem, $ak^{(\alpha-1)} - \delta = n + \lambda$, i.e., the net (of depreciation) return to capital equals the steady-state natural growth rate. The solution value is $k^* = 6.8$.

Table 1. Adjustment Speed in Years as $yt$ Approaches a Limit of $y_\infty$ with different $d$

<table>
<thead>
<tr>
<th>y0:y00</th>
<th>pt</th>
<th>φ=0.41</th>
<th>φ=0.41</th>
<th>φ=0.41</th>
<th>φ=0.41</th>
<th>φ=0.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>125%</td>
<td>d=0.50</td>
<td>0.25</td>
<td>1.1803</td>
<td>1.2956</td>
<td>1.6108</td>
<td>1.8347</td>
</tr>
<tr>
<td>0.5</td>
<td>2.9348</td>
<td>3.1751</td>
<td>3.8037</td>
<td>4.2278</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>10.5046</td>
<td>10.9686</td>
<td>12.0964</td>
<td>12.8008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d=0.31</td>
<td>0.25</td>
<td>1.4766</td>
<td>1.6614</td>
<td>2.2181</td>
<td>2.6668</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>3.7019</td>
<td>4.0917</td>
<td>5.1993</td>
<td>6.0315</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>13.5347</td>
<td>14.3033</td>
<td>16.2854</td>
<td>17.6282</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d=0.22</td>
<td>0.25</td>
<td>1.6264</td>
<td>1.8534</td>
<td>2.5742</td>
<td>3.1995</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>4.0948</td>
<td>4.5765</td>
<td>6.0084</td>
<td>7.1532</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>15.1394</td>
<td>16.0999</td>
<td>18.6578</td>
<td>20.4751</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In these denotations, $d$ is the debt and GDP ratio, $\phi$ is the risk premium value, $pt$ is the ratio of the different growth rate attainment level as defined in equation (30), $y0:y00$ is the ratio of initial level growth rate to the long term equilibrium growth rate.

When external debt is considered to be exogenous, it becomes an independent variable to be incorporated into capital growth rate function through which external debt affects production growth. The marginal real cost of external borrowing is the sum of the risk-free interest rate and risk premium, which is an increasing function of the ratio of the stock of the net external debt to the capital stock. But in table 1, we let the risk premium be fixed at the 0.41 level. Thus the capital growth rate will be determined by exogenous debt-GDP ratio, real world interest rate and the country’s propensity to save out of its disposable income. In this nonlinear relationship with capital, the exogenous external

---

5 The parameter values of the Philippine economy are adopted from Mariano and Villanueva (2005).
debt factor plays both positive and negative roles. Presenting in the extended MV model, firstly in equation (20) external debt as the exogenous factor directly affects the capital accumulation growth rate with both directions, positively and negatively. As donor aid $\tau$ earmarked for education, health and other labor-productivity enhancing expenditures and the parameter $\tau$ may be allowed to vary positively with learning coefficient $\theta$ which is a parameter decides the technology change. We have the assumption that the external debt is directed into growth orientations so it may boost $\tau$ to increase and thus increase $\theta$, in this way, external debt may also affect the technology. Then through capital accumulation change rate into equation (25), external debt affects the production growth rate change. The results of Table 1 report that with higher debt levels, the adjustment speed apparently rises. With the assumptions that external debt is directed into growth orientations and the usage is effective, the higher the level of debt, the more the country gains in terms of capital resource and other positive effects for growth fund as we have discussed in the models. Here the upper level external debt to the GDP ratio is settled at 50%, with the assumption that the net marginal product of capital exceeds the capital market effective real interest rate, we allow debt accumulation go beyond the country’s steady-state growth rate. Meanwhile, the burden of external debt is not too high for the country to shoulder and does not create too many negative effects. So under these circumstances, higher external debt is more helpful for growth of the indebted country and thus shortens the adjustment time needed to reach the long term equilibrium growth rate.

We make some extensions on the calculation in Table 1 and obtain the following figures.
Figure group 1: Reports for Table 1 Extensions

\[ \psi = 0.32 \]

The colors in the Figure group 1 corresponds to Red: \( y_0: y_\text{o}=125\% \), Yellow: \( y_0: y_\text{o}=110\% \), Green: \( y_0: y_\text{o}=90\% \), and Blue: \( y_0: y_\text{o}=75\% \)

---

\(^6\) The colors in the Figure group 1 corresponds to Red: \( y_0: y_\text{o}=125\% \), Yellow: \( y_0: y_\text{o}=110\% \), Green: \( y_0: y_\text{o}=90\% \), and Blue: \( y_0: y_\text{o}=75\% \)
However, the extension figures in Table 1 do not totally confirm our hypotheses. Even if we let the external debts go much higher than the proper scale, and the external debt to GDP ratio goes up to nearly 90 percent, and we still get a higher adjustment speed. The results are similar when different risk premium values are put in for the same test. As per our theoretical analysis, foreign borrowing has a positive impact on investment and growth up to a certain threshold level; beyond this level, however, its impact could be adverse. The threshold level of external debt face value is estimated by Clements and Bhattacharya (2003) to be around 50 percent of GDP. But here, the counterintuitive calculation results may come from the model structure we have chosen. To set the external debt as exogenous may not be applicable to the economic reality.

In the following Table 2, we change the angle to fix the external debt to GDP ratio and change the risk premium level. Our simulation result confirms the expectation in Table 2: when the indebted countries shoulder higher risk premium levels, which indicates paying higher interest rates, they will grow with faster adjustment speeds to approach long-term equilibrium. Here, we also make some extensions for Table 2. The results are similar to the extensions for Table 1, so we put them in the Appendix.
Table 2. Adjustment Speed in Years as $v_t$ Approaches a Limit of $v_\infty$ with different $\varphi$

<table>
<thead>
<tr>
<th>$\varphi$</th>
<th>pt</th>
<th>y0:y00</th>
<th>y0:y00</th>
<th>y0:y00</th>
<th>y0:y00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>125%</td>
<td>110%</td>
<td>90%</td>
<td>75%</td>
</tr>
<tr>
<td>0.32</td>
<td>d=0.22</td>
<td>1.5433</td>
<td>1.7464</td>
<td>2.3722</td>
<td>2.893</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>3.8766</td>
<td>4.3059</td>
<td>5.5503</td>
<td>6.5108</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>14.2435</td>
<td>15.0943</td>
<td>17.3195</td>
<td>18.8584</td>
</tr>
</tbody>
</table>

$\varphi=0.41$

<table>
<thead>
<tr>
<th></th>
<th>pt</th>
<th>y0:y00</th>
<th>y0:y00</th>
<th>y0:y00</th>
<th>y0:y00</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1.4766</td>
<td>1.6614</td>
<td>2.2181</td>
<td>2.6668</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>3.7019</td>
<td>4.0917</td>
<td>5.1993</td>
<td>6.0315</td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>13.5347</td>
<td>14.3033</td>
<td>16.2854</td>
<td>17.6282</td>
<td></td>
</tr>
</tbody>
</table>

$\varphi=0.47$

<table>
<thead>
<tr>
<th></th>
<th>pt</th>
<th>y0:y00</th>
<th>y0:y00</th>
<th>y0:y00</th>
<th>y0:y00</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1.4352</td>
<td>1.6092</td>
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<tr>
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<tr>
<td>0.9</td>
<td>13.1003</td>
<td>13.8205</td>
<td>15.6621</td>
<td>16.8954</td>
<td></td>
</tr>
</tbody>
</table>

$^a$In these denotations, $d$ is the debt and GDP ratio, $\varphi$ is the risk premium value, $p_t$ is the ratio of the different growth rate attainment level as defined in equation (30), $y_0:y_00$ is the ratio of initial level growth rate to the long term equilibrium growth rate.
V. Simulation of Adjustment Speed
------When External Debt Is Endogenous

Key Assumptions

In the second part of the simulation, we can see the joint dynamics when there are interactions with factors such as external debt, capital accumulation, and effective interest rate when we assume external debt is partially endogenous as in equation (18). Another important assumption here is that external debt is properly directed into growth oriented departments or investment, and the usages are effective. Therefore, the following discussion is based on the extended model (16), (17), (18).

Simulation Process

Here, we define $x$, $H$ and $J$ as the following:

$$
x = \begin{pmatrix} k \\ d \end{pmatrix}$$

$$H(k,d) = \frac{k}{d} = \frac{s((1+\tau)k^{\alpha-1} - rd)}{(1-d)} + [(ak^{\alpha-1} - \delta - r)d/(1-d)] - \frac{\delta}{(1-d)} - \theta k - \lambda. \quad (17)$$

$$J(k,d) = \frac{d}{d} = ak^{\alpha-1} - \delta - r \quad (18)$$

Partially differentiating text equations (16), (17) and (18) with respect to $k$ and $d$, and evaluating and linearizing the equations in the neighborhood of the steady state yield,

$$\dot{k} = H(k,d) = [H(k^*, d^*) + k*H_d(k^*, d^*)] + [k*H_d(k^*, d^*)](d - d^*) \quad (32)$$

$$\dot{d} = J(k,d) = [d*J_d(k^*, d^*)] + [J(k^*, d^*) + d*J_d(k^*, d^*)](d - d^*) \quad (33)$$

$$\ddot{x} = \left( \begin{array}{c} \dot{k} \\ \dot{d} \end{array} \right) = \left( \begin{array}{cc} \frac{\partial k}{\partial k} & \frac{\partial k}{\partial d} \\ \frac{\partial d}{\partial J} & \frac{\partial d}{\partial J} \end{array} \right) \left( \begin{array}{c} k - k^* \\ d - d^* \end{array} \right) = A(x - x^*) = \left( \begin{array}{cc} a_{11} & a_{12} \\ a_{21} & a_{22} \end{array} \right) (x - x^*)$$

(34)
\[
\dot{x} = \begin{pmatrix} k \\ d \end{pmatrix} = A \begin{pmatrix} k \\ d \end{pmatrix} - \begin{pmatrix} a_{11}k^* + a_{12}d^* \\ a_{21}k^* + a_{22}d^* \end{pmatrix} = Ax - B
\]

\[
a_{11} = \left\{s\alpha (1+\tau) + \alpha^2d^* \right\} k^{*^{\alpha-1}} - (sd^* + d^*)(r + \varphi d^* + \alpha \varphi \varepsilon k^*^{(\alpha-1)}) - \delta d^*/(1-d^*) - 2\theta k^* - \delta/(1-d^*) - n - \lambda.
\]

\[
a_{12} = -s(r k^* + 2\varphi d^*k^* + \varphi \varepsilon k^*^{\alpha})/(1-d^*) +\left\{s(1+\alpha(1+d^*))k^{\alpha} - (1+sd^*+d^*)(r k^* + \varphi d^*k^* + \varphi \varepsilon k^*^{\alpha}) - \delta(1+d^*)k^{*^{2}}\right\}/(1-d^*)^2 - \delta k^*/(1-d^*)^2
\]

\[
a_{21} = (\alpha - \varepsilon \varphi)(\alpha - 1)k^{*^{\alpha-2}}d^*
\]

\[
a_{22} = (\alpha - \varepsilon \varphi)k^{*^{\alpha-1}} - 2\varphi d^* - \delta - r
\]

Still using the example of the Philippines, as external debt is partially endogenous, we assume \(\varphi = 0.41\) to derive one level of the adjustment speed. Solving out the following equations, we get \(k^* = 6.84, \quad d^* = 0.0695, \quad r^* = 0.0897\)

\[
\{s[(1+\tau)k^{\alpha-1} - r^*d^*]/(1-d^*) - \delta/(1-d^*) - 0k^* - n - \lambda = 0
\]

\[
d^* = [(\alpha - \varphi \varepsilon)k^{\alpha-1} - \delta - r]/\varphi
\]

\[
r^* = r + \varphi [d^* + \varepsilon k^{\alpha-1}]
\]

Thus with the constant values we can get the matrix

\[
A = \begin{pmatrix} a_{11} & a_{22} \\ a_{21} & a_{22} \end{pmatrix} = \begin{pmatrix} -0.1128 & 0.0835 \\ -0.0006 & 0.0285 \end{pmatrix}
\]

We skip the process similar to simulation (I), and get the following relationship equations

We find the eigenvalues and eigenvectors associated with matrix \(A\) as \(\alpha\). We find the diagonal matrix \(D\) and the matrix of eigenvectors, with the relation \(V^{-1}AV = D\).

We therefore have

\[
(A - \alpha I) V = \begin{pmatrix} -0.112 - \alpha & -0.0835 \\ -0.0006 & -0.0285 - \alpha \end{pmatrix} V = \begin{pmatrix} v_1 \\ v_2 \end{pmatrix}
\]

\[
D = \begin{pmatrix} -0.12 & 0 \\ 0 & -0.021 \end{pmatrix}, \quad V = \begin{pmatrix} 1 & 1 \\ 0.0089 & -0.91 \end{pmatrix}, \quad V^{-1} = \begin{pmatrix} 1 & 9.1 \\ 0.081 & -9.1 \end{pmatrix}, \quad B = \begin{pmatrix} -0.766 \\ -0.006 \end{pmatrix}
\]

We define \(\dot{z} = V^{-1}\dot{x} = V^{-1}(Ax - B) = V^{-1}AVV^{-1} - V^{-1}B = Dz - V^{-1}B\)

\[
\begin{pmatrix} z_1 \\ z_2 \end{pmatrix} = V^{-1}\begin{pmatrix} k \\ d \end{pmatrix} \Rightarrow \begin{pmatrix} \dot{z}_1 \\ \dot{z}_2 \end{pmatrix} = V^{-1}\begin{pmatrix} \dot{k} \\ \dot{d} \end{pmatrix},
\]

32
So
\[
\begin{align*}
\dot{z}_1 &= -0.12z_1 + 0.896 \\
\dot{z}_2 &= -0.021z_2 + 0.001
\end{align*}
\]

We solve the two differential equations and get
\[
\begin{align*}
z_1 &= 7.47 + c_1 e^{-0.12t} \\
z_2 &= 0.048 + c_2 e^{-0.021t}
\end{align*}
\]
as \( \mathbf{x} = V \dot{z} \)

we get
\[
\begin{align*}
k_t &= C_1 e^{-0.112t} + C_2 e^{-0.029t} + 6.84 \\
d_t &= 0.0072C_1 e^{-0.112t} + 1.003C_2 e^{-0.029t} + 0.0695
\end{align*}
\]

From the basic model:
\[
Y / L = k^\alpha \quad \dot{y} / y = g_t = \alpha \dot{k}_t / k_t + y_\infty
\]

When \( t=0 \), we assume that \( y_0 \) is some percentage of \( y \) and the long term equilibrium value to get
\[
g_0 = \alpha \dot{k}_0 / k_0 + y_\infty \quad \text{and with assumption } d_0 = 0.22, \text{ two conditions to solve for } C1 \text{ and } C2,
\]
then we have \( k_t = 0.1882e^{-0.029t} - 5.325e^{-0.112t} + 6.84 \), which when plugged into the equation and solved, we can get the adjustment time according to different percentage assumptions. The process of solving for time path of with different \( \varphi \) and \( d \) values are the same (the calculation process with software Maple in the Appendix). Therefore, we get the following adjustment speed timetable.
Table 3. **Adjustment Speed in Years as $y_t$ Approaches $y_\infty$ with different $\phi$ and $d$**

<table>
<thead>
<tr>
<th>$\phi=0.32$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125%</td>
<td>115%</td>
<td>110%</td>
<td>105%</td>
</tr>
<tr>
<td>$0.25$</td>
<td>$0.451$</td>
<td>$0.883$</td>
<td>$1.408$</td>
<td>$2.826$</td>
</tr>
<tr>
<td>$0.5$</td>
<td>$0.795$</td>
<td>$1.421$</td>
<td>$2.155$</td>
<td>$4.051$</td>
</tr>
<tr>
<td>$0.9$</td>
<td>$4.104$</td>
<td>$6.098$</td>
<td>$8.071$</td>
<td>$12.167$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\phi=0.41$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125%</td>
<td>115%</td>
<td>110%</td>
<td>105%</td>
</tr>
<tr>
<td>$0.25$</td>
<td>$0.453$</td>
<td>$0.887$</td>
<td>$1.415$</td>
<td>$2.85$</td>
</tr>
<tr>
<td>$0.5$</td>
<td>$0.799$</td>
<td>$1.428$</td>
<td>$2.169$</td>
<td>$4.096$</td>
</tr>
<tr>
<td>$0.9$</td>
<td>$4.149$</td>
<td>$6.187$</td>
<td>$8.214$</td>
<td>$12.444$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\phi=0.47$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
<th>$y_0:y_{00}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125%</td>
<td>115%</td>
<td>110%</td>
<td>105%</td>
</tr>
<tr>
<td>$0.25$</td>
<td>$0.468$</td>
<td>$0.933$</td>
<td>$1.516$</td>
<td>$3.207$</td>
</tr>
<tr>
<td>$0.5$</td>
<td>$0.836$</td>
<td>$1.53$</td>
<td>$2.385$</td>
<td>$4.803$</td>
</tr>
<tr>
<td>$0.9$</td>
<td>$4.857$</td>
<td>$7.768$</td>
<td>$11.083$</td>
<td>$20.382$</td>
</tr>
</tbody>
</table>

*a* In these denotations, $d$ is the debt and GDP ratio, $\phi$ is the risk premium value, $pt$ is the ratio of the different growth rate attainment level as defined in equation (30), $y_0:y_{00}$ is the ratio of initial level growth rate to the long term equilibrium growth rate.

We can see from the results in Table 3 that when external debt is endogenous as in equation (18), the proportionate change in debt level is determined by the difference between the expected marginal products of capital, net of depreciation, and the marginal real cost of funds in the international capital market. The main channel through which external debt affects growth is capital accumulation with equation (17)&(18) and also oppositely the growth affects the debt level, plus indirectly and mutually through technology change with equation(14), these compose the interactions between the external debt and growth. When the initial state of external debt is above the long run equilibrium, the joint dynamics force $k$ to decrease and move towards the equilibrium with a possible time path as indicated in Table 3. Results show that with relatively higher risk spread level, the adjustment speed lowers and needs more time to approach the long run equilibrium, in opposition to the time path trend of Table 1 and 2. The probable explanation for this situation may be that the other parameters and exogenous variables of the growth model have the ability to slow down the adjustment speed which more than offsets the ability of external debt to increase the speed even when the initial state of the
growth rate is closer to the long term equilibrium. From the other side, the external debt ratio shifts with changes in the economy’s propensity to save out of national disposable income, the marginal cost of funds in world capital markets, the depreciation rate, the growth rates of the working population and technical change, so at the same time, different growth states also affect the external debt change. The proportionate increase in net external debt is decided by the economy’s steady-state output growth, and the external debt/output ratio stabilizes at a constant level with the condition that the net marginal product of capital matches the marginal cost of funds at the equilibrium capital-labor ratio. Overall, when the external debt is assumed to be endogenous, the adjustment speed is much higher than that of a closed-economy endogenous growth model (Villanueva 1994 IMF Paper) or when it is assumed to be exogenous in the first part of the simulation based on the Villanueva-Mariano model. Subsequently, when external debt is endogenous, as \( \phi \) increases, the sensitivity of risk spread or premium increases, and the possibility of credit rationing owing to the prohibitive cost of borrowing rises up, and this may prevent the optimal level of external debt to be reached, thus affecting the long term equilibrium of the output. The second part of the simulation process with the assumption of external debt being endogenous is closer to the real situation.
VI. Nonparametric Regressions

The above simulation results are mainly based on the assumption that the external debt level is within the proper scale of 50 percent of the external debt to GDP ratio. This is reasonably directed into growth orientations with effective management. When these conditions are relaxed, using the real-life situation of the Philippines economy, we try to use nonparametric regression to examine the dynamic relation between external debt and GDP. Nonparametric analysis relaxes the highly restrictive assumption of linearity in linear regression and replaces it with the much weaker assumption of a smooth regression function. One main drawback is it cannot test specific functions and the risk of bias would be high if important factors are neglected in the nonparametric regression. The Mariano and Villanueva model indicates that

\[ y_t = \alpha_k + y_{\infty} \]

\[ k_t = \{s[(1 + \tau)k^{a-1} - rd] / (1 - d)\} + [(\alpha k^{a-1} - \delta - r)d / (1 - d)\} - [\delta / (1 - d)\} - \theta k - n - \lambda \]

\[ d_t = \alpha k^{a-1} - \delta - r \]

Thus both \( y \) and \( d \) are endogenous and jointly determined. This chapter will discuss nonparametric regressions of the form

\[ \Delta y_t = f(d_{t-1}) + u_t \] (40)

This is an initial step that would provide additional insights in the debt-growth relationship. It should be pointed out at the outset that the results in this chapter are extremely preliminary and should be interpreted with caution because of the simultaneity and omitted variables in the specified model.

Linear Regression Test

Before we do the nonparametric regressions, we do the test regression by assuming \( \Delta y_t \) and \( d_{t-1} \) have a linear relationship, and we get

\[ \Delta y_t = 0.000864157599 + 0.0007364346601 \times d_{t-1} \] (41)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.000864</td>
<td>0.029547</td>
<td>0.029247</td>
<td>0.9768</td>
</tr>
<tr>
<td>LNDEBTLAG1</td>
<td>0.000736</td>
<td>0.002427</td>
<td>0.303478</td>
<td>0.7629</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.002042</td>
<td></td>
<td></td>
<td>0.009823</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>-0.020134</td>
<td></td>
<td></td>
<td>0.008608</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.008694</td>
<td></td>
<td></td>
<td>-6.610807</td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.003401</td>
<td></td>
<td></td>
<td>-6.532078</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>157.3540</td>
<td></td>
<td></td>
<td>0.092099</td>
</tr>
<tr>
<td>Durbin-Watson stat</td>
<td>1.778989</td>
<td></td>
<td></td>
<td>0.762924</td>
</tr>
</tbody>
</table>

Then we get the positive coefficient but this is of slight magnitude, and the adjusted R-squared is quite low even to the extent of being negative. The t-statistics prove to be quite low and the probability is high. We cannot reject the hypothesis that the true coefficient is zero against a two-sided alternative even at the five percent significance level. The Durbin-Watson statistic is less than 2 which means that there is evidence of positive serial correlation in the residuals. The F-statistic is also low and Prob(F-statistic)—the marginal significance level of the F-test is high. Again, we cannot reject the null hypothesis that the slope coefficients are equal to zero. The report tells us that the regression is statistically insignificant. The assumptions that the estimated coefficients are asymptotically and normally distributed can hardly be satisfied in our case. In particular, the linear regression cannot address the issue of endogeneity for external debt, so we must turn alternatively to nonparametric approaches for the purpose of estimation.

**Nonparametric Approaches**

Generally, we use nonparametric estimations to approximate the \( \Delta y_t = f(d_{t-1}) + u_t \) arbitrarily closely, when the error term is i.i.d. Let \( \hat{f}(d) \) be a consistent estimator of \( f(d) \), because \( f(d) = f(d) + (n)^{-1} \sum_{i=1}^{n} u_i \), and \( E(u_t) = 0 \).
Let \( h \) be a window width that is smaller than the distance between the discrete values taken by \( d_{t-1} \), and let \( \psi_i = (d_{t-1} - d) / h \), \( i = t-1 \), with a kernel \( K(\psi_i) \) be the estimator as the form
\[
\hat{f}(d) = \frac{\sum_{i=1}^{n} K(\psi_i) \Delta y_i}{\sum_{i=1}^{n} K(\psi_i)} \quad (42)
\]
Here, \( h \) is small and approaching zero, \( n \) increases to keep the observations close enough to \( d \), and \( \psi_i \) is large so kernel \( K \) will be small. Notably, the corresponding observations get low weight to determine \( \hat{f}(d) \). Also when the law of large numbers can be applied to \( u_i \), as \( n \to \infty \), there is an increasing number of values of \( d_{t-1} \) that is close to \( d \) of all the factors together to provide the best local estimate of \( f(d) \).

(i) **Nadaraya-Watson Kernel Estimator**

Let \( \omega_n (d) = \omega_n (d_{t-1}, d) \) represent the weight we assign to the number \( t \) observation to \( \Delta y_i \) which depends on the distance of \( d_{t-1} \) to the point \( d \) and with the feature that the weight is high when the distance is small and low when the distance is large. Here, there is an implicit assumption that \( f(d) \) is smoothed over \( d \) and \( \Delta y_i \) contains information about \( f(d) \) whenever \( d_{t-1} \) is near to \( d \).
\[
\hat{f}^1(d) = \sum_{i=1}^{n} \omega_n^1 (d) \Delta y_i = \sum_{i=1}^{n} \Delta y_i K\left( \frac{d_{t-1} - d}{h} \right) / \sum_{i=1}^{n} K\left( \frac{d_{t-1} - d}{h} \right) \quad (43)
\]

(ii) **Nearest Neighbor (NN) Estimator**

We introduce another kind of estimator to determine the relationship between debt and growth. The key feature of the Nadaraya-Watson estimate is that it gives weight to observations corresponding to the symmetric neighborhood distance of \( d_{t-1} \) around \( d \).

\[\text{7 The equations in this process and in the following sections are mainly taken from Adrian Pagan and Aman Ullah, 1999, “Nonparametric Econometrics”, Cambridge University Press, pp. 83-94}\]
Similarly, the $k$th nearest neighbor k-NN estimator is also a weighted average in the weight sequence.

Here the k-NN estimator is

$$\hat{f}^2(d) = \sum_{t=1}^{n} \omega_{nt}^2(d) \Delta y_t = k^{-1} \sum_{t=1}^{n} I_{kt}(d) \Delta y_t$$

(44)

$$\omega^2_{nt}(d) = k^{-1} I_{nt}(d)$$

(45)

Specifically, $k$ represents the assigned number to decide how many observations of external debt are to be picked out to make the average which is in the nearest neighborhoods of $d$.

In relation to uniform weights, we can rewrite the estimator as

$$\hat{f}^2(d) = \frac{1}{k} \sum_{j=1}^{k} y_j^*(d)$$

(46)

Here $y_j^*$ is the one of $y_j$ with $d_{t-1}$ as closest to $d$, thus it is likely that $y_j^*$ is the one of $y_j$ with $d_{t-1}$ as the second closest to $d$, etc. so the function of $k$ is just similar to the window width $h$ for the kernel estimator. There are two special cases: if the estimator has triangular (T) or quadratic (Q) weights, $j$ is also ordered according to the distance measure with $d$

$$\omega_{nj}^T = 2(k - j + 1)/(k(k + 1))$$

$$\omega_{nj}^Q = 6(k^2 - (j - 1)^2)/(k(k + 1)(4k - 1))$$

for $k > j$

$$\omega_{nj}^T = \omega_{nj}^Q = 0$$

for $k < j$

The general nearest neighbor (G-NN) estimator is shown in the following and we let $s$ be the distance between $d$ and its $k$th nearest neighbor

$$\hat{f}^2(d) = K\left(\frac{d_{t-1} - d}{s}\right) \Delta y_t / \sum_{t=1}^{n} K\left(\frac{d_{t-1} - d}{s}\right)$$

(47)

(iii) **Local Linear Estimator**

From the above analysis, there are equations for the weighted average property of $f(d)$

$$\sum \Delta y_t K_t = \sum K_t f(d)$$
The solution for this is \( \hat{f}(d) = (\sum K_i)^{-1} \sum \Delta y_i K_i = \bar{y}_k, \)

where \( K_i = K\left(\frac{d_{i-1} - d}{h}\right) \) and \( \bar{y}_k \) is the weighted average of \( \Delta y_i \) values.

The local linear approximation fits a line with the form

\[
\hat{f}^3(d) = \bar{y}_k - \hat{\beta}(\tilde{d}_{i-1} - d)
\]

\[
\hat{\beta} = \hat{\beta}(x) = \frac{\sum (\Delta y_i - \bar{y}_K) (d_{i-1} - \tilde{d}_K) K_i}{\sum (d_i - \tilde{d}_K) K_i}
\]

\[\tilde{d}_k = \sum d_{i-1} K_i / \sum K_i\]

(iv) **Polynomial Regression Estimator**

Polynomial regression estimator is built upon the extension of local linear estimator in case the \( (d_{i-1} - d) \) can be stochastic or nonstochastic, polynomial or even exponential. If the \( f(d) \) has bounded higher order derivatives, \( d_{i-1} \) can be a vector. When estimating \( f(d) \) on the boundaries of the support of \( d_{i-1} \), the optimal window width is proportional to \( n^{-1/5} \) within the support but has a greater propensity to change near the boundary. This is indicated in the research of Hall et al. (1995) when they assumed that the \( f(d) \) has two bounded continuous derivatives and \( K_i \) satisfies the usual condition of kernel regression as standard normal density, and it is compactly supported.

Expanding \( f(d_{i-1}) \) around \( d \) to get

\[
f(d_{i-1}) = f(d) + \frac{\partial f}{\partial d}(d^*)(d_{i-1} - d), \text{ where } d^* \text{ lies between } d_{i-1} \text{ and } d, \text{ so there is}
\]

\[
f(d_{i-1}) = d + \beta(d^*)(d_{i-1} - d)
\]

Since \( E(\Delta y_i | d_{i-1}) = f(d_{i-1}) \), the objective function

\[
\sum (\Delta y_i - f(d_{i-1}))^2 K_i = \sum (\Delta y_i - d - \beta(d^*))^2(d_{i-1} - d)^2 K_i
\]

This equation ensures that the observations are very close to \( d \) and the \( \beta(d^*) \) is close to the constant \( d^* \) which lies between \( d_{i-1} \) and \( d \).
Data Description

Our sample period is set from February 1993 to November 2004. The frequency of data is quarterly. The Philippines GDP is seasonally adjusted with 1985 price in Philippine Peso, and obtained from the database DataStream. The data of external debt is drawn from the IMF database International Financial Statistics. Other than the quarterly data of external debt, from the first quarter of 1993 to the fourth quarter of 2000, the data is on a yearly basis. Based on the Spline method, we disaggregated the data to get the quarterly data. We take natural logarithm for both external debt and GDP, and do regressions between the growth rates of GDP (in the figures as GROWTH_DS) and lag ones of log debt (appearing as LNDEBTLAG1 in the figures). Here as the assumptions and specific functional forms are all relaxed to real situation testing, the external debt level is using the absolute value of debt after being taken logarithm instead of following in the MV model to use the ratio of net external debt.

Regression Result Analysis

Figure group 2: Effect of external debt on growth with fixed window width

(i) Nadaraya-Watson Kernel Estimator

(ii) Nearest Neighbor (NN) Estimator

As mentioned in footnote 1 in this is thesis “external debt“ is mentioned to a country’s total external debt that includes the stock of debt owed to nonresident governments, businesses and institutions and repayable in foreign currency, goods or services. Here the data used is gross external debt of Philippines.
Based on the above theoretical analysis, the nonparametric regressions with the different estimators show the regression results in the Figure group 2. The estimations from the four different nonparametric estimators are similar, so we have put them together for discussion. It is apparent that the effect of external debt on GDP growth is substantially nonlinear, not simple and not monotonous. As mentioned before, if we let $h$ be a window width (bandwidth) that is smaller than the distance between the discrete values taken by $d_{i-1}$, and let $\psi_i = (d_{i-1} - d_i) / h$, $i = t-1$, with a kernel $K(\psi_i)$, the estimator will be shown as the form

$$
\hat{f}(d) = \frac{\sum_{i=1}^{n} K(\psi_i) \Delta y_i}{\sum_{i=1}^{n} K(\psi_i)} = \frac{\sum_{i=1}^{n} \Delta y_i K\left(\frac{d_{i-1} - d_i}{h}\right)}{\sum_{i=1}^{n} K\left(\frac{d_{i-1} - d_i}{h}\right)}
$$

Before we assume that the window $h$ is fixed for Nadaraya-Watson Kernel Estimation, we should just simply adjust $h(d_{i-1})$, so that different observations $m$ can be included in the window width. The $m/n$ is termed the span of the kernel smoother. Varying the window width of the kernel estimator controls the smoothness of the estimated regression function. Particularly, larger window widths produce smoother results. In the illustration above, we let the Eviews automatically select the $h=0.2327$, but now we adjust the window widths to be gradually larger, and observe the following effects:
Figure group 3: Effect of external debt on growth with varied window width
(Using Nadaraya-Watson Kernel Estimation)

(i) Window Width $h=0.30$
(ii) Window Width $h=0.50$
(iii) Window Width $h=0.70$
(iv) Window Width $h=0.90$

The three other kinds of nonparametric regression have common properties with Nadaraya-Watson Kernel Estimations that with larger bandwidth such as $h$ values from 0.3, 0.5, 0.7 to 0.9, the results are smoother with higher window width sensitivity.

Overall, results of our four kinds of nonparametric regressions report the relation is insignificant between external debt and growth in the sample period of Philippine economy. This is totally different from the effects of external debt on growth that we
expected from our simulations for adjustment speed. Possible reasons could be given from three angles for the insignificance. Firstly, the nonparametric method relaxes restrictive assumptions under which the simulations are placed and also relax the MV growth model as functional form. Secondly, the estimation method excluding specific parameters may have omitted variables with its simplification. Third, the sample data is from one country not cross border and within relatively special period. Comparing the results with the earlier hypothesis, it may imply that in the actual economic situation of the Philippines, the assumptions can hardly be justified: although sometimes external debt level is high, external debt management may not be effective or debt funds have not been channeled into growth orientations and do not work for productivity enhancement. Another possible explanation is that the negative impacts of high external debt level have offset its benefits to growth. A high external debt level at the same time may reduce the government’s incentive to carry out structural and fiscal reform, since any strengthening of the fiscal position could intensify pressures to repay foreign creditors, according to Krugman (1988). For a developing country like the Philippines which is in debt, high cost of risk premium and payments for interest raises the budget deficit, reduces public savings and diverts the significant amount of government revenues from being used in the areas of infrastructure, human capital and crowd out credit available for investment to facilitate growth. Structural reform is definitely needed as accelerator to sustain higher growth rate. One main objective should be to explore and develop comparative advantage to boom export and augment foreign reserve as the strength to reduce external debt level (this would be tested following). Governmental fiscal spending must also be beneficial to increase national production competence as much can be realized, expenditures to other channels should be limited. Along all the process, government fund management inefficiency and bureaucracy should be reduced as much can be realized.

ii. Effect of Growth on External Debt

In the above regression analysis, we let the GDP growth be the dependent variable and the lagging external debt to be the independent variable. The regression results of
four kinds of nonparametric regressions show us that external debt has no significant effect on the Philippines’ GDP growth. While we know from reduced models that interactions exist between external debt and growth; however, growth also affects external debt through capital accumulation and other mutual factors. Similarly, using the four nonparametric regressions to estimate the effect of GDP growth on external debt borrowing, we have \( \Delta d_t = m(y_{t-1}) + \varepsilon_t \)

And now we have

\[
\hat{m}(y_t) = \frac{1}{n} \sum_{i=1}^{n} \Delta d_i K\left(\frac{y_{t-1} - y}{h}\right) / \sum_{i=1}^{n} K\left(\frac{y_{t-1} - y}{h}\right) 
\]

(51)

We use the same set of data as the first part, and take the logarithm for both external debt and GDP quarterly data in the sample period from the first quarter of 1993 to the fourth quarter of 2004. We consider the regression upon the external debt growth rate as a dependent variable and the lagging GDP as an independent variable.

**Figure group 4: Effect of growth on external debt with fixed window width**

(i) Nadaraya-Watson Kernel Estimator

(ii) Nearest Neighbor (NN) Estimator
Although the regression results on the effect of GDP growth on external debt is also nonlinear, not monotonous and not simple, especially with the Nearest Neighbor and Polynomial Regression Estimator, compared with the effect of external debt on growth, the effect of growth on external debt is more significant. The results of the Nadaraya-Watson Kernel Estimator and Local Linear Estimator are similar, showing us that external debt growth rate may rise up when GDP increases at a relatively lower level and earlier period, but external debt growth rate may decrease when GDP increases to a relatively high level in the later period. The turning point is shown closely at the GDP level of Php. 23,000 million.

Figure group 5: Effect of Growth on External Debt with varied window width
In Figure group 5, we do the Nadaraya-Watson Kernel nonparametric regressions with higher bandwidth $h$ to 0.08 and 0.09 level, and come up with smoother regression results. However, the main results we get from the above still remain the same.

For the Polynomial Regression Estimation, the Polynomial Degree shown by Eviews is 2, so we adjust the Polynomial Degree to be 1 and 3 in Figure group 6. We see that the result reacts sensitively to the polynomial degree, and is smoother when the weight is linear and is more volatile with the addition of quadratic or triangular weights.

**Figure group 6: Effect of growth on external debt with varied polynomial degree**

The results confirm the suspicion that when the GDP level of the Philippines is low, and the economy production capability and capital accumulation are low, there is more need for external debt; whereas when the economy develops to a higher level with more capital accumulation to some point (around GDP 23000 million of Philippine peso level from the figures), the need for external debt goes down. Notably, the effect of growth on external debt is not very significant. It is also possible that with better growth performance, the government may succeed in reducing the stock of external debt and enhance domestic savings, thereby decreasing the sensitivity of the risk premium to external debt, since there would be lower cost paid by interest saving, and more capital resource can be channeled into growth orientations and revenue-raising paths.

Furthermore, the export as the main resource for foreign reserve and capital accumulation should have more direct effect on external debt than on GDP growth. The
theory foundation is also based on the reduced model and the channel of export that impacts on external debt is still capital accumulation. To simulate the effect of export on external debt, we still use the abovementioned method to address the endogeneity as both of them are endogenous, and still utilize the advantage of nonparametric regression which does not need specific functional form, but just to transfer the regression equation to \( \Delta d_t = n(x_{t-1}) + \epsilon_t \). Then, we let \( x_{t-1} \) to denote the lagging export of the Philippines. For nonparametric regression with

\[
\hat{n}(x_t) = \frac{\sum_{i=1}^{n} \Delta d_i K\left(\frac{x_{t-1} - x}{h}\right)}{\sum_{i=1}^{n} K\left(\frac{x_{t-1} - x}{h}\right)}
\]

the external debt data is the same as above. The export data is drawn from IFM database International Financial Statistics, and the sample period is set from the first quarter of 1993 to the fourth quarter of 2004, with quarterly frequency. The data is measured with reference to the 1985 Philippine peso price and with FOB term of trade. We also take natural logarithm for export, and considered regressions upon the external debt growth rate (in the figures as DEBT\_GTH) as the dependent variable and the lagging Export as the independent variable (in the figures as LAGEXPORT).

**Figure group 7: Effect of export on external debt with fixed window width**

(i) Nadaraya-Watson Kernel Estimator  
(ii) Nearest Neighbor (NN) Estimator
(iii) Local Linear Estimator  
(iv) Polynomial Regression Estimator

Though the results shown from the four nonparametric regression estimates are not significant, we still recognize the weak effect of export on external debt. When export is at a relatively low level, the external debt growth rate rises when export increases. The export increases capital accumulation continuously, and the turning point comes at around the first quarter of 1998 when export volume reaches Php. 77,853 million. After the turning point, the external debt growth rate decreases with export increase. Similar to growth effect on external debt, export brings revenue, but when the revenue accumulation is not high enough, the need for external debt support still keeps going up until the revenue is enough to reduce the debt stock. In particular, the export revenues mainly raise foreign reserve accordingly to address the debt borrowing from foreign countries.
VII. Summary and Conclusion

Based on the refinement of neoclassical growth model for a closed economy, incorporating global capital markets and the assumption of learning by doing that makes technical change endogenous, the model of Mariano and Villanueva (2005) gives us the foundation with which to explain the joint interactions between external debt and growth. The main channel through which external debt affects growth is capital accumulation. External debt directly affects growth in a nonlinear way through capital accumulation, and the positive linear relation with the interest rate. Through capital accumulation, external debt also indirectly affects technology change and hence has a long-term effect on growth. On the other hand, the proportionate change of debt level is determined by the difference between the expected marginal products of capital, net of depreciation, and the marginal real cost of funds in the international capital market. From this perspective, growth lowers the marginal products of capital as a major negative fiscal shock, brings down primary surpluses, and thus makes a given level of debt more burdensome.

Our simulation analysis is based on the extended growth model of Mariano and Villanueva (2005) to derive the adjustment time path from an initial state to converge to long-term equilibrium steady state. The parameters we used in the simulation are derived from the actual state of the Philippines economy. We assume that the external debt is properly directed into growth-oriented departments or investment and its usage is effective. With the debt exogenous assumption, the higher the risk premium or debt level, the faster is the adjustment speed. With the assumption that the external debt is endogenous, the results in Table 3 show that with relatively higher risk spread level, GDP growth needs more time to converge. As risk premium increases, the sensitivity of risk spread also increases, and the possibility of credit rationing owing to prohibitive cost of borrowing rises up. This effect may prevent the optimal level of \( d \) from being reached and thus affect the long-term equilibrium of output. Likewise, it may also take a lot longer for it to be reached. Overall, the adjustment speed is observed to be lower with higher risk premium when external debt is treated endogenously in the model.

We should emphasize that the above results are based on the restrictive assumptions that the debt level is within the proper scale and also that the external debt is properly
directed into growth orientations like investment and export promotion, and the debt usage/management is effective. Without these assumptions, the results of the effect of external debt on growth may be totally different. If debt funds have not been channeled into growth orientations or do not work effectively for productivity enhancement, the negative impact of high external debt level may be more than offset its benefits and slow down the growth. High external debt level may reduce the governments’ incentive to carry out structural and fiscal reforms. Meanwhile, for a developing country that is in debt like the Philippines, the structural reform is definitely needed as a catalyst to sustain higher growth rate. The high cost of risk premium and payments for interest raise the budget deficit, reduce public savings and divert the significant amount of government revenues away from being used for infrastructure and human capital. They also crowd out credit available for investment to facilitate growth.

Most importantly, for indebted countries like the Philippines which want to achieve higher adjustment speed, debt should be channelled into growth orientation paths and enhance productivity. Government and private sectors should reform the debt management to make it effective. As we can see from nonparametric regression, increasing GDP growth and export have positive effects on reducing the external debt burden when GDP and export volume have come to a certain high level. These actions should keep the domestic saving higher than the risk premiums and borrowing interest to decrease debt stock and sustain long-term growth. At the same time, another key point is to keep the foreign savings and reduce the external debt burden. If the countries in debt do not use the external debt properly to enable effective growth, the external debt level may not be relevant to the higher adjustment speed of the economy. To realize the positive effect of external debt, debt management, related macroeconomic policy and environment are very important. Indebted government must make out scientific schedule to adjust the repayments for external debt accordingly with proper domestic fiscal policy. Other outsource supportive measures to facilitate developing countries growth, such as equity or direct fund management in which the direct management agencies will have greater incentives to deliver better results, should be alternatives to traditional external debt method. To the end, the production growth based on indebted country’s own
comparative advantage decides the country’s “Ability to Pay” for the external debt and long term growth.

As mentioned above, the nonparametric empirical test is only a tentative first step in examining the relation between external debt and growth. For a more careful examination, further research still needs to address the difficulties in dealing with the simultaneous relation between external debt and growth. There are omitted variables in the nonparametric regression analysis reported here. On the data side, the analysis should use panel data for cross-border regression over longer time periods for comparison. Based on this further research, more detailed and accurate reference can be given to policy makers and international agencies for proper handling of issues related to external debt.
Appendix

Figure group: Reports for Table 2 Extensions

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The colors in the figures correspond to Red: $y_0: y_{oo}=125\%$, Yellow: $y_0: y_{oo}=110\%$, Green: $y_0: y_{oo}=90\%$, Blue: $y_0: y_{oo}=75\%$
List of References


