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An Analytical Framework for the New Partnership for Africa's Development (NEPAD)

Author :

Diery Seck

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Chapter 2

AN ANALYTICAL FRAMEWORK FOR THE NEW PARTNERSHIP FOR AFRICA'S DEVELOPMENT (NEPAD)

Diery Seck

INTRODUCTION[1]

The New Partnership for Africa's Development (NEPAD) is the brainchild of African Heads of State. It is the synthesis of a number of independently developed initiatives aimed at achieving the common goal of setting a course of action that will result in rapid growth and development for Africa. In 2001, the idea of African Renaissance advocated by President Thabo MBeki of South Africa was taken into account by the Millennium African Plan (MAP) that he proposed jointly with the President of Algeria, Abdel Aziz Bouteflika, and the President of Nigeria, Olusegun Obasanjo. The Omega Plan was separately developed by the President of Senegal Abdoulaye Wade while the Economic Commission for Africa proposed the Compact Initiative for Africa. The three documents were merged into a new plan entitled The New African Initiative, later renamed NEPAD. NEPAD is a sub-program of the African Union (AU) and its governance includes a Steering Committee of seven African Heads of State, an Implementation Committee of twenty African Heads of State and a Secretariat.

The goal of NEPAD is to help Africans, through a common vision and shared convictions, to eradicate poverty and to set their countries, individually and collectively, on a course leading to sustainable growth and development. The main focus of NEPAD is to identify areas in which concerted efforts could help attain this objective. These priority areas can be arbitrarily grouped into two main categories: the sectoral priorities and the behavioral priorities. Priority sectors of NEPAD include Agriculture, Infrastructure, Education, Health, Environment, Energy and New technologies of information and communication.[2] The behavioral priorities focus on Democracy and political, economic and corporate governance, Peace and security, Regional Co-operation and integration, Promoting diversification, Capacity building and Market access. These priorities are termed behavioural to denote areas in which Africans consider a significant change in actors' behaviour to be a prerequisite for the continent's development.

One striking contrast in the current debate on NEPAD is that while the initiative enjoys strong political support at the highest level in Africa and among developed countries, technical contributions designed to help provide it with a scientific perspective are hardly available. As a result, the rationale that underlies its implementation is driven by action-oriented policymakers with little benefit of the analytical insight of researchers.

The main issue that is addressed in this paper can be summarized by the following question: "What is the best use for funds made available for the NEPAD initiative?" As a result, it only deals with the financial aspects of NEPAD. The present exercise seeks to propose a mathematical formulation of the goal of the NEPAD initiative and provide a solution to the optimization problem, making use of the tools of the modern theory of financial economics. The feasibility of the proposed solution is illustrated by a numerical example that attempts to demonstrate the simplicity and realism of the solution. The aim of the study is also to suggest an approach that is applicable to all African countries irrespective of their level of development or economic and political characteristics.

The remainder of the paper is organized as follows. The next section depicts the sources of funding for NEPAD, the allocation of funds across sectors and the specification of the productive sector of a typical African country. Section 3 sets the stage for the formulation of the optimization problem regarding the financing of the economy, derivation of the solution, presentation of a numerical example in the form of a simulation and a general discussion of the implications of the model for policy purposes. Section 4 examines briefly the non sectoral challenges of NEPAD and a few concluding remarks end the paper.

REPRESENTATION OF THE NEPAD OBJECTIVE

The financing matrix

Let us assume that the economy of country K has S sectors which represent the priority sectors of NEPAD at the country level plus one additional sector that captures all economic activity not included specifically in NEPAD and a pseudo-sector that includes NEPAD regional projects. There are four main sources of financing for the economy, namely public funds, development aid, debt (domestic and foreign) and private sector investment (domestic and foreign direct investment (FDI)).

A break-down of financing of NEPAD from all possible sources by sector would give for country K.

$$F_K = \begin{bmatrix} F_{1,1} & F_{1,2} & F_{1,3} & F_{1,4} \\ F_{2,1} & F_{2,2} & F_{2,3} & F_{2,4} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ F_{S,1} & F_{S,2} & F_{S,3} & F_{S,4} \end{bmatrix} \quad (1)$$

Where $F_{i,j}$ represents the amount of financing for sector i from the source of funding j. In this context subscript j denotes public funds if it is 1, development aid if it is 2, debt if it is 3 and private sector investment (domestic and FDI) if it is 4.

For any sector i, total financing of the sector is given by:

$$F_i = \sum_{j=1}^{4} F_j \quad (2)$$

Likewise, for all sectors combined, we have total public funding, total aid funding, total debt funding and total private sector investment, given respectively by:

$$GO_K = \sum_{i=1}^{S} F_{i,1} \quad (3a)$$

$$AI_K = \sum_{i=1}^{S} F_{i,2} \quad (3b)$$

$$DE_K = \sum_{i=1}^{S} F_{i,3} \quad (3c)$$

$$PS_K = \sum_{i=1}^{S} F_{i,4} \quad (3d)$$

GO_K = total public financing of the economy,
AI_K = total development aid received by the country,
DE_K = total debt financing and
PS_K = total private sector investment.

From (1) and (2), we have:

$$F_K = \begin{bmatrix} F_1 \\ F_2 \\ . \\ . \\ . \\ . \\ F_S \end{bmatrix} = T_K \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ . \\ w_S \end{bmatrix} \tag{4}$$

The elements F_i for i = 1 to S denote the amounts of financing allocated to the S sectors respectively. T_k is a positive constant. According to equation (4) the financing of the economy of country K is equal to the sum of the funds allocated to all the priority sectors of NEPAD, to the non-NEPAD sectors and to the regional projects of NEPAD.

The total financing of the economy is allocated to the various sectors by multiplying the total dollar amount, $T_{K,}$ by weights specific to each of the S sectors of the economy, w_i. Equation (4) underscores the challenge of country K namely that, in order to adequately address its development challenges, it needs to determine the optimal allocation across its sectors of the amount $T_{K,}$ using the vector of sectoral weights $W_{K.}$

$$W_K = \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ . \\ w_S \end{bmatrix}$$

Specification of the productive sector

Assume that productivities of the various sectors of country K's economy are fixed in the short run and are equal to their respective incremental capital-output ratios. These ratios can be represented in vector form as follows:

$$K_K = (K_1, K_2, \ldots\ldots\ldots\ldots, K_S) \tag{5}$$

Given (4) and (5), one obtains the incremental output for sector i resulting from the new financing:

$$Y_i = K_i \times F_i \tag{6}$$

and for the incremental output of the whole economy as:

$$Y_K = K_K \times F_K = K_K \times T_K \times W_K \tag{7}$$

where Y_i = incremental output of sector i for country K

Y_K = incremental output for country K's economy

Equation (7) warrants some comments. First, we have $K_K \times W_K$ which is the weighted average incremental capital-output ratio for the economy. It is a linear combination of the capital-output ratios of the various sectors of the economy multiplied by the weights with which total financing is allocated across sectors. Second, total output can be increased in the long run by raising the sectoral capital-output ratios through superior production processes e.g. better technology or more skilled human capital.

In the short run, output can be increased by raising the amount of financing available for the economy, F_K, or by improving upon the allocation of funding across sectors, if it is not optimal i.e. by finding the optimal set of weights. It is noteworthy that the total level of financing of the economy is expected to change quickly as the economy expands because growth is assumed to generate more public and private domestic funding, attract more foreign direct investment and secure higher levels of foreign credit. The sectoral allocation of financing is also expected to change with economic growth because growth induces modifications in the relative degrees of competitiveness of individual sectors and possible changes in the behaviour of economic agents. This last point will be discussed further in the next section.

Finally, it appears from (7) and (4) that, in order to increase aggregate output, policymakers have two instruments over which they have some control: total funding, F_K, and the allocation of funds across the sectors of the economy, W_K. It is assumed that in the short run, Government has reached its maximum capacity to fund the economy and has implemented policies whose impact on its capacity to borrow cannot change in the short run. Consequently, only private investment can change in the short run, in response to new investment opportunities or new assessment of future economic outcomes based on the information set available to domestic and foreign private economic agents. For the sake of simplicity, it is further assumed that any Government policy that can possibly influence the behaviour of private sector operators is subsumed in its resource allocation decision. This implies that private agents observe W_K at a given period t and only modify their behaviour during subsequent periods but not at period t itself. Hence, for any period t, W_K, is a policy variable largely under the control of the Government. As a result, Government cannot set the level of total funding of the economy which is fixed in the short run, but can allocate the funds to achieve a targeted level of aggregate output.

The remainder of the paper will focus on the identification of the optimal allocation of financing of sectors under NEPAD. The rates of growth of output can be expressed for sector i and for the economy respectively as:

$$r_{i,t} = \frac{Y_{i,t}}{Y_{i,t-1}} - 1 \tag{8a}$$

$$R_t = \frac{Y_t}{Y_{t-1}} - 1 \tag{8b}$$

$r_{i,t}$ = rate of growth of output of sector i for period t,
R_t = rate of growth of output of country K's economy for period t.

OPTIMIZATION OF SECTORAL FINANCING UNDER NEPAD

The assumptions of the model

The specifications of the financing and production processes of the economy are presented above. Now the optimization problem of the economy needs to be formulated taking into account the aggregate preferences that characterize country K's economy. It is postulated that policymakers of country K conduct policies that are consistent with a quadratic utility function, which can be expressed as follows:

$$U(Y_K) = aY_K - bY_K^2 \tag{9}$$

within the space $Y_K < \dfrac{a}{2b}$

$U(Y_K)$ = utility derived from output of country K; parameters a et b are positive constants.

The quadratic utility function has the undesirable properties of having increasing absolute risk aversion and increasing relative risk aversion. These features are not consistent with observed ordinary economic behaviour. However, the quadratic utility function describes risk aversion, a characteristic that is consistent with the behaviour of African economic agents, given the high level of uncertainty surrounding economic outcomes on the continent. Furthermore, the quadratic utility function can be conveniently summarized by the first two moments of the probability distribution of the variable on which utility is based, namely the expected value and the variance of aggregate output.

The following additional simplifying assumptions serve to describe the typical African economy. First, considering the high level of uncertainty in the economy, there is no riskless asset. Second, Government and private agents can divest (negative investment) from a sector and use the proceeds to invest in another sector. Net assets divested from a given sector correspond to a negative weight in the financing vector $W_{K.}$ Third, the production processes of the various sectors are distinct and independent. As a result one cannot obtain the output of one sector by forming a linear combination of the outputs of other sectors. This allows the economy to have a variance-covariance matrix of the rates of growth of its sectors that is non singular.

The objective function and its solution

From (8a) and (8b) we have:

$$R_K = W_K^T R_i = \sum_{i=1}^{S} w_i r_i \tag{10}$$

where R_i is the column vector of rates of growth of the S sectors of the economy and the superscript T indicates a transposed matrix.

To identify the optimal weights of sectoral funding, country k must solve the following constrained objective function:

$$Min \quad \frac{1}{2} W_K^T V_K W_K$$

subject to:

$$(a) \quad \overline{R}_K = W_K^T \overline{R_i} = \sum_{i=1}^{S} w_i E(r_i)$$

$$(b) \quad W_K^T 1 = \sum_{i=1}^{S} w_i = 1 \tag{11}$$

V_K : Positive-definite variance - covariance matrix of the rates of growth of the S sectors.

$\overline{R_i}$: is the column vector of the expected rates of growth of the S sectors. It is the expected value of R_i .

$\overline{R}_K = E(R_K)$

1 is the column vector of ones

E (.) is the expectations operator.

According to (11) the country seeks to minimize the standard deviation of its rate of growth subject to an expected rate of growth that is a linear combination of the expected rates of growth of all the sectors multiplied by their respective optimal weights given that the total of the weights is equal to one.

The solution is obtained by solving the Lagrangian problem:

$$L = \frac{1}{2} W_K^T V_K W_K + \lambda \left(\overline{R}_K - W_K^T \overline{R_i} \right) + \gamma \left(1 - W_K^T 1 \right) \tag{12}$$

where λ and γ are Lagrange multipliers. Posing the necessary and sufficient first-order conditions as follows:

$$0 = \frac{\partial L}{\partial W_K} = V_K W_K - \lambda \overline{R_i} - \gamma 1 \tag{13a}$$

$$0 = \frac{\partial L}{\partial \lambda} = \overline{R}_K - W_K^T \overline{R_i} \tag{13b}$$

$$0 = \frac{\partial L}{\partial \mathrm{g}} = 1 - W_K^T \mathbf{1} \tag{13c}$$

The solution for the optimal weights, W_K^* ,is:

$$\begin{aligned} W_K^* &= \mathrm{l}\ V_K^{-1}\overline{R_i} + \mathrm{g} V_K^{-1}\mathbf{1} \\ &= \frac{\mathrm{C}\,\overline{R}_K - \mathrm{A}}{\mathrm{D}} V_K^{-1}\overline{R_i} + \frac{B - A\overline{R}_K}{D} \\ &= \frac{1}{\mathrm{D}}\left[B\left(V_K^{-1}\mathbf{1}\right) - A\left(V_K^{-1}\overline{R_i}\right)\right] + \frac{1}{D}\left[C\left(V_K^{-1}\overline{R_i}\right) - A\left(V_K^{-1}\mathbf{1}\right)\right]\overline{R}_K \\ &= \mathrm{g} + \mathrm{h}\overline{R}_K \end{aligned} \tag{14}$$

With

$$A = \overline{R_i}\ V_K^{-1}\mathbf{1}$$

$$B = \overline{R_i}^{\mathrm{T}}\ V_K^{-1}\ \overline{\mathrm{R}_\mathrm{i}}$$

$$C = \mathbf{1}^T V_K^{-1}\mathbf{1}$$

$$D = BC - A^2$$

$$g = \frac{1}{\mathrm{D}}\left[B\left(V_K^{-1}\mathbf{1}\right) - A\left(V_K^{-1}\overline{R_i}\right)\right]$$

$$h = \frac{1}{D}\left[C\left(V_K^{-1}\overline{R_i}\right) - A\left(V_K^{-1}\mathbf{1}\right)\right]$$

A numerical example

The model presented above will now be used in a numerical simulation on a fictitious African country that has the following economic characteristics. The economy has three sectors numbered 1 through 3. It is postulated that two mutually-exclusive economic states of nature numbered 1 and 2 could materialize with probabilities of occurrence set respectively at 70% for the first state of nature and 30% for the second one. The number of sectors or of states of nature could be increased substantially but is kept low for ease of exposition. Table 1 summarizes the rates of growth of each of the three sectors under the various states of nature. The column entitled E(Ri) gives the expected rate of growth for each sector, taking into account the probability attached to each state. The last column gives the standard deviation of the growth rate for each sector. For most African countries, the basic information that is needed to build a table similar to Table 1 can be obtained from technicians and analysts serving in ministries and government agencies. Information usually collected preparation for the drafting of the Budget or of a multi-year development plan could also serve to build the table.

Table 1. Simulated economic performance of sectors under different states of nature, in %

	STATE 1	STATE 2	Expected growth rate E (Ri)	Standard deviation
PROBABILITY	70.0	30.0		
Growth Sector 1	8.0	11.0	8.9	1.37
Growth Sector 2	6.0	7.0	6.3	0.46
Growth Sector 3	10.0	4.0	8.2	2.75

The numerical solution is obtained using equation (14). Different rates of expected output growth are hypothesized in order to examine the behaviour of the model under various scenarios. Details of the calculations are presented in Appendix A. The results are displayed in Table 2. For the sake of realism, the range of rates of output growth used in the simulation corresponds to what African countries are likely to achieve if their development efforts are successful. The lowest rate is 7%, which is required for African countries to reduce poverty by one half by 2015, and the highest is 9%.

Table 2. Sectoral allocation of funding for different levels of expected output growth, in %

Financing Structure #	Expected rate of output growth	Standard deviation of output growth	Funding for Sector 1	Funding for Sector 2	Funding for Sector 3
1	7.0	0.323	19.7	70.4	9.9
2	8.0	0.433	53.6	30.3	16.1
3	9.0	0.542	87.5	-9.9	22.4

Source: Author's calculations. For details see Appendix A.

The following lessons can be drawn from the results of the simulation. First, admittedly, the policy question underlying the model and spelled out in the introduction focuses on the best use of NEPAD funds. The model provides a specific answer to that question in an unambiguous manner. In this regard, the underlying policy process consists of setting a target growth rate and solving for the allocation of funding across sectors that minimizes the variability of aggregate output growth. Given that the efficient frontier is a continuous convex function, any target growth rate that is equal to or higher than that of the minimum-variance sectoral structure of the economy can yield an optimal funding structure that is also mean-variance efficient.

Second, as is shown is Table 2, each target growth rate is associated with a sectoral allocation of funding that is specific. This structure is a function of all the factors that affect the model, namely the vector of expected growth rates of individual sectors, the variance-covariance matrix of the sectors' rates of output growth and the growth rate targeted by policymakers. Furthermore, as will be discussed in the next section, this sectoral allocation of funding may change over time as the country increases its wealth, even if all the parameters mentioned above remain constant.

The third lesson is illustrated by the trade-off between level of output growth and variability of output growth. Table 2 shows that for high expected rates of output growth, the economy faces more variable output growth, which underscores the need for policymakers to pay attention to the social consequences of economic downturns during high growth episodes. The results also underscore the fact that equal funding of all the sectors of the economy is most likely not an optimal solution and cannot be used as a rule-of-thumb. The fourth lesson relates to the negative weight attached to Sector 2 in the third funding structure of Table 2. It clearly shows that one of the funding sources for NEPAD is divestiture from existing sectors that, from an optimality standpoint are over-invested, and use of the proceeds to fund investment in other sectors.

Implications of the solution

The first implication of the solution is that policymakers are neither trying to exclusively maximize the rate of output growth, nor to exclusively minimize the variability of output growth. Their quadratic utility function dictates that they maximize output growth for a given level of its variability or to minimize its variability for a given level of expected output growth.

In this respect, reduction in the level of output variability can be obtained through diversification of financing across various sectors. This diversification effect is higher the more uncorrelated the outputs of the various sectors are. Indeed we have for any sector i:

$$\frac{\partial Var(R_K)}{\partial w_i} = 2w_i\sigma_i^2 + \sum_{j=1}^{S} w_j\sigma_{ij} \tag{15}$$

where $Var(R_K) = \sum_{i=1}^{S}\sum_{j=1}^{S} w_i w_j \sigma_{ij}$

$Var(R_K)$ = variance of output growth for country K

σ_{ij} = covariance between rates of output growth for sectors i and j

W_i, W_j = weights of sectors i and j respectively in the total financing of the economy

Equation (15) shows that, as the economy becomes more and more diversified, w_i tends towards 0 and sector i's contribution to the overall variability of the economy's output growth is increasingly attributed to the average covariance of its rate of change of output with the rates of output change of the other sectors.

This first implication has an impact on the degree of specialization pursued by the economy. For each level of aggregate output growth, the optimal financing weights across sectors that minimize variability gives a structure of the economy in terms of relative sizes of the sectors that lies on an efficient frontier that is convex in a mean-variance space. As a result, a policy aimed at maximizing output growth would lead to a degree of specialization in one or a limited number of sectors that offer the highest rates of output growth but no scope for diversification across sectors. Consequently expected output growth would be higher than under a more diversified structure of the economy, but also more volatile.

However, a maximum output growth policy could arguably approach optimality if the economy enjoys protection against adverse outcomes through some form of insurance mechanism whose payoffs are highly correlated with the downturns of aggregate output.

Alternative insurance scheme payoffs can be tied to decreases in the level of exports or in government fiscal revenues but their effectiveness would depend on their respective correlations with downward variations of aggregate output.

The second implication of the model is that for the implementation of NEPAD, a country can set its target expected rate of output growth and calculate the optimal allocation of sectoral financing that is consistent with the target. In other words, the real decision is to set the target growth rate, not the sectoral weights. To see this, consider equation (14) above:

$$W_K^* = g + h\overline{R}_K$$

Bearing in mind that g and h are vectors, if the country chooses a target expected growth rate $\overline{R}_K$, the corresponding optimal weights for sectoral financing, W_K^*, obtain automatically. The level of variability of output growth also obtains by calculating the variance using the same weights and the variance-covariance matrix, V_K.

The third implication relates to a country's level of economic safety measured in this model by the variability of its output growth. Countries that are prone to wide fluctuations in their economic performance without significant means for immediate relief may focus on the uncertainty surrounding economic growth rather than growth itself, at least in the short run. In this case, they may pursue safety-first strategies, namely keep the variability of output growth reasonably low.

For mean-variance efficient financing structures of the economy we have:

$$Var(R_K) = \left[g + h\overline{R}_K\right]' V \left[g + h\overline{R}_K\right] \tag{16a}$$

$$= \frac{C}{D}\left(\overline{R}_K - \frac{A}{C}\right)^2 + \frac{1}{C} \tag{16b}$$

Noting that equation (16b) is the equation of a parabola with vertex: $\left(\frac{1}{C}, \frac{A}{C}\right)$,we can identify the minimum-variance efficient structure of the economy as having an expected rate of output growth equal to $\frac{A}{C}$ and a variance of output growth equal to $\frac{1}{C}$.

The importance of the identification of the minimum-variance efficient sectoral structure of the economy cannot be overstated. First, the main characteristic of this structure is that no alternative structure of financing of the sectors of the economy can yield a lower level of variability; and it has a higher level of expected output growth than any other financing structure with an equal level of variability, if it exists.

If a country can reach a rate of expected output growth that is higher than is currently the case given its present level of output variability, it must be considered to lie below the efficient frontier. In such a case optimal allocation of sector financing would put it back on the frontier and a welfare gain would be achieved. For an efficiently managed economy, the lowest performance that can be expected, in terms of aggregate output, is: $\overline{R_K} = \frac{A}{C}$, with a variability no higher than Var (R) $= \frac{1}{C}$.

However, a country's economic sustainability may be compromised if its expected rate of output growth is lower than the rate of growth of its population. Given the convexity of efficient frontier, the model uncovers a striking paradox. Many poor African countries are characterized by a high rate of population growth and low output growth. In some cases population growth exceeds aggregate output growth. One implication of the model is that such countries should try and structure their sectoral financing so as to achieve growth rates of aggregate output that are higher than the rate of growth of their populations. However, on the efficient frontier, high growth rates correspond to higher variability of growth. Considering the high social cost of adverse economic fluctuations for very poor countries, safety-first policies may be pursued which, even if they are mean-variance efficient, may be associated with expected rates of growth of aggregate output that are lower than population growth. Such policies would deliberately reduce per capita income. Indeed, the high degree of risk aversion of very poor countries may lead them to choose policies that are expected to increase poverty with lower variability of output over policies that are expected to reduce it but with much higher output variability!

The last implication of the solution relates to the constancy of the optimal set of financing weights. It should be noted that equation(4) is valid only in the short run. Cass and Stiglitz (1970) have shown that the relative weights, w_i, remain constant as wealth increases only in the case of utility functions that display either constant absolute risk aversion or constant relative risk aversion. The quadratic utility function that is postulated for this model does not fit that description because it portrays positive absolute risk aversion and positive relative risk aversion. As a result, the optimization model that is derived for NEPAD depicts the problem and proposes a solution in a specific time frame: the short run. However, the exercise can be repeated recursively as wealth increases, which, in each round, leads to a new optimal short run financing solution, taking new parameters into account Whether this succession of short run optimization exercises would be consistent with an optimal long run strategy is a question that cannot be answered with the present model and begs further analysis.

NON SECTORAL ISSUES OF NEPAD

One of the distinct features of NEPAD is that its agenda includes sectoral priorities, which are the main topic of this paper, and behavioural priorities. These behavioural priorities constitute what are considered to be the enabling factors for the success of the initiative. They can be listed as follows: democracy and political, economic and corporate governance, peace and security, regional co-operation and integration, promoting diversification, capacity building and market access

To some extent, they describe the way in which Africans want to conduct their affairs. While success in their pursuit would have a significantly positive impact on the economies of African countries, they do not in themselves constitute channels for wealth creation which is the ultimate goal of NEPAD. The behavioural priorities of NEPAD also differ from the sectoral priorities because their formulation for the purpose of finding optimal rules of conduct is different altogether. Indeed, the need to take into account the existence of multiple actors in the specification of the problem to be resolved and its zero-sum-game nature would require optimization tools that fall outside the scope of the more limited sectoral financing problem tackled here. This underscores the need for analytical frameworks that are best suited for this task namely political science, diplomacy and game-theoretic approaches. Naturally, the question may arise as to whether NEPAD would succeed if optimal solutions cannot be found for the behavioural priorities listed above. One may also wonder if improved sectoral allocation that results in better economic conditions would help achieve the behavioural priorities. These complex questions cannot be satisfactorily answered here but would certainly warrant further studies on how to make NEPAD successful.

CONCLUSION

The purpose of the paper was to propose a scientific approach to the formulation of the NEPAD optimization problem and a feasible solution. Based on a number of realistic assumptions that describe the economies of African countries, policymakers are portrayed as seeking to implement measures that foster growth of output while minimizing economic volatility. Formal mathematical treatment of the problem has resulted in an optimal solution of funding allocation among the sectors of the economy that can be easily applied in practice by African countries irrespective of their individual economic and political circumstances. Given the underlying assumptions of the model, the solution that is obtained is not fixed over time and may require recursive optimizations as the country's level of output increases or major shifts occur in the relative risk and productivity profiles of its sectors.

The formulation of the NEPAD problem shows that countries seek to identify the optimal financing weights to allocate to their sectors. However, they cannot decide on the weights themselves but must set a target rate of output growth which translates into a set of optimal weights for the economy. Formal recognition that policymakers try and avoid economic volatility implies that countries do not necessarily aim for the highest possible growth rate, but settle instead for the combination of expected growth and volatility of growth that they are comfortable with. Given the underlying trade-off between expected output and its uncertainty, it is shown that very poor African countries may choose slow growth policies that reflect their safety-first concerns, thereby leading to deliberate increase in poverty if their target rate of aggregate output is lower than the rate of growth of their populations. For such countries NEPAD is not enough and they may require further support to break out of the poverty trap.

Finally, the paper addresses the optimization problem of the sectoral priorities of NEPAD but not the behavioural priorities because while the former can be tackled with the usual tools of financial economics, the latter require formulation of their optimization problem in an entirely different context that would require the contribution of other fields in social sciences. In this regard, more scientific studies on NEPAD are needed to bring added fuel to the current debate.

Appendix A : Model simulation for the case of expected aggregate growth rate of 8%

	STATE 1	STATE 2	$\overline{R_i} = E(r_i)$
PROBABILITY	0,7	0,3	
Sector 1 (S1)	0,08	0,11	0,089
Sector 2 (S2)	0,06	0,07	0,063
Sector 3 (S3)	0,10	0,04	0,082

$$V_K = \begin{pmatrix} 1.8910^{-4} & 6.3\ 10^{-5} & -3.78\ 10^{-4} \\ 6.3\ 10^{-5} & 2.1\ 10^{-5} & -1.26\ 10^{-4} \\ -3.78\ 10 & -1.26\ 10^{-4} & 7.5\ 10^{-4} \end{pmatrix} \Rightarrow V_K^{-1} = \begin{pmatrix} -1.59\ 10^{19} & 9.53\ 10^{19} & 0 \\ 9.53\ 10^{19} & -1.27\ 10^{20} & 1.59\ 10^{19} \\ 0 & 1.59\ 10^{19} & 3.97\ 10^{18} \end{pmatrix}$$

$$A = \mathbf{1}^T V_K^{-1} \overline{R_i} = (1 \quad 1 \quad 1) \begin{pmatrix} -1.59\ 10^{19} & 9.53\ 10^{19} & 0 \\ 9.53\ 10^{19} & -1.27\ 10^{20} & 1.58\ 10^{19} \\ 0 & 1.58\ 10^{19} & 3.97\ 10^{18} \end{pmatrix} \begin{pmatrix} 0.089 \\ 0.063 \\ 0.082 \end{pmatrix}$$

$$= 7.69\ 10^{18}$$

$$B = \overline{R_i}^T V_K^{-1} \overline{R_i} = (0.089 \quad 0.063 \quad 0.082) \begin{pmatrix} -1.59\ 10^{19} & 9.53\ 10^{19} & 0 \\ 9.53\ 10^{19} & -1.27\ 10^{20} & 1.58\ 10^{19} \\ 0 & 1.58\ 10^{19} & 3.97\ 10^{18} \end{pmatrix} \begin{pmatrix} 0.089 \\ 0.063 \\ 0.082 \end{pmatrix}$$

$$= 6.295\ 10^{17}$$

$$C = \mathbf{1}^T V_K^{-1} \mathbf{1} = (1 \quad 1 \quad 1) \begin{pmatrix} -1.59\ 10^{19} & 9.53\ 10^{19} & 0 \\ 9.53\ 10^{19} & -1.27\ 10^{20} & 1.58\ 10^{19} \\ 0 & 1.58\ 10^{19} & 3.97\ 10^{18} \end{pmatrix} \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$

$$= 8.34\ 10^{19}$$

$$D = BC - A^2 = -6{,}741\ 10^{36}$$

$$g = \frac{1}{D}\left[B\left(V_K^{-1}\mathbf{1}\right) - A\left(V_K^{-1}\overline{R_i}\right)\right] = \begin{pmatrix} -2.02 \\ 3.50 \\ -0.34 \end{pmatrix}$$

$$h = \frac{1}{D}\left[C\left(V_K^{-1}\overline{R_i}\right) - A\left(V_K^{-1}\mathbf{1}\right)\right] = \begin{pmatrix} 33.89 \\ -40.15 \\ 6.26 \end{pmatrix}$$

If $\overline{R}_K = 0.08$ then

$$w_K^* = g + h\overline{R}_K = \begin{pmatrix} 0.54 \\ 0.30 \\ 0.16 \end{pmatrix}$$

$$\sigma_K^2 = w_K^{*T} V_K w_K^* = \begin{pmatrix} 0.54 & 0.30 & 0.16 \end{pmatrix} \begin{pmatrix} -1.59\ 10^{19} & 9.53\ 10^{19} & 0 \\ 9.53\ 10^{19} & -1.27\ 10^{20} & 1.58\ 10^{19} \\ 0 & 1.58\ 10^{19} & 3.97\ 10^{18} \end{pmatrix} \begin{pmatrix} 0.54 \\ 0.30 \\ 0.16 \end{pmatrix}$$

$$= 1.78\ 10^{-5}$$

Notes

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2. NEPAD Secretariat (2001), p. 1.

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