The forecasts of economic and military trends presented in this report are based on a hierarchically linked model in which (1) GDP (gross domestic product) or gross national product (GNP)\(^1\) is estimated from a simple Cobb-Douglas production function, (2) per-capita GDP is calculated using demographic data for each country in combination with the GDP estimates, (3) military spending is derived as a specified (sometimes varying) proportion of GDP, and (4) military capital stock is estimated as a specified (sometimes varying) proportion of military spending allocated to new military investment \textit{minus} depreciation of the previously accumulated military capital stock.

Use of the CES (constant elasticity of substitution) model is based on its commendable transparency, convenience for calculation purposes, and its modest and tractable data requirements compared, say, with input-output models, translog production functions, or time-series regressions. The method used to derive military spending and military capital estimates was selected for similar reasons of tractability, simplicity, and transparency.

The model used in the forecasts consists of five variables (GDP, employed labor, nonmilitary capital, military spending, and military capital, each of which carries a time subscript) and seven parameters—annual employment growth; annual growth of nonmilitary

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\(^1\)In most cases, the estimates we present are for GDP. In the case of India, the estimates are for GNP because the country data from which the estimates were made used GNP rather than GDP as a starting point. The accounting relation between GDP and GNP is defined as: \(\text{GDP} = \text{GNP} - \text{net factor income from abroad.}\)
capital; total factor productivity ($\tau$), representing the annual rate of technological change; the labor share in GDP ($\alpha$); the proportion of GDP devoted to military spending ($\gamma$); the proportion of military spending devoted to military investment ($\pi$); and the annual depreciation rate ($\delta$) of the previously accumulated military capital stock. The model is first applied to data covering the period from 1985 through 1996, and the parameters are estimated by calculating their mean values and variances over this period, and in some cases by a time regression of the parameter values in each year to determine trends.2

We then use these parameter values and appropriate values for the input variables based on the authors’ explicit judgments about whether these trend values are likely to persist, or why they may be expected to change and by how much. These judgments are described and reflected in the individual country sections of Chapter Four.

The model summarized below was used for each country, together with adjustments and elaboration to allow for data problems or other country-specific circumstances.

$$Q = e^{\tau t} \cdot L^\alpha \cdot K^{(1-\alpha)}$$  \hspace{1cm} (1)

$$MS_t = \gamma GDP$$  \hspace{1cm} (2)

$$MK_t = \pi MS_t + MK_{t-1}(1-\delta)$$  \hspace{1cm} (3)

In Equation (1):

$Q = GDP$

$\tau = $ rate of technological change (total factor productivity)

$t = $ years covered in the projections beginning with 1994

$\alpha = $ labor share in GDP

$L = $ labor input in each year

2See Appendix B.
$K$ = capital input in each year.

In Equation (2):

$\text{MS}_t$ = military spending in year $t$

$\gamma$ = proportion of GDP devoted to military spending.

In Equation (3):

$\text{MK}_t$ = military capital stock in year $t$

$\pi$ = proportion of military spending devoted to procurement of equipment and construction

$\delta$ = annual depreciation rate on the previously accumulated military capital stock.

In Equation (1), the civil capital inputs ($K$) and labor inputs ($L$), and their corresponding growth rates, were estimated for each country. The capital input, $K$, for each year was calculated by adding each year’s net new investment to the previous year’s civil capital stock. Note that this depreciation rate on the civil capital stock is not necessarily the same as the depreciation rate on the military capital stock.\(^3\)

Equation (1) can be expressed in a form that is useful for our forecasts by taking the logarithmic derivatives of the variables with respect to time. The result is Equation (1a):

$$\frac{\dot{Q}}{Q} = \tau + \alpha \left( \frac{\dot{L}}{L} \right) + (1 - \alpha) \left( \frac{\dot{K}}{K} \right)$$

Equation (1a) stipulates that the rate of growth in GDP is equal to the annual growth of total factor productivity (technological progress) $\tau$, plus the rate of growth in employment multiplied by the share of labor income in GDP ($\alpha$), plus the rate of growth in the capital stock multiplied by the share of capital income in GDP, $(1 - \alpha)$. The rate of

\(^3\)The initial year 1994 capital stock figures were derived from the Penn World Table (version 5.7) and an expanded set of international comparisons, 1950-1988 (see Robert Summers and Alan Heston, *The Quarterly Journal of Economics*, May 1991) and from the prior estimates in Wolf et al., 1989.
growth in total factor productivity in each country in recent years can be estimated from the known values of the other variables in Equation (1a).

The labor and capital income shares, \( \alpha \) and \( (1 - \alpha) \), respectively, are also based on the respective data and experience of each country.

Similarly, the estimates of the parameter \( \gamma \), representing the share of GDP devoted to military spending, are calculated from each country’s average share in recent years, combined with explicit judgments by the authors of this report, as noted above.

Measurement of the military capital stock presents complex and difficult theoretical and empirical problems. Among these difficulties are the following: First, the “services” provided by military equipment are difficult to define and quantify; second, the same piece of equipment can provide varying levels of effective service depending on the type of conflict, terrain, adversaries, allies, training, and morale of the forces, as well as various contingency-specific circumstances. Our methodology measures the value of the military capital stock based on procurement cost. This implicitly assumes that the value of military services provided by a particular piece of equipment or structure, relative to others, averaged over an appropriate set of scenarios, is equal to its procurement cost. This assumption is convenient, but arbitrary and untested.

A further difficulty in measuring military capital relates to the possibility of accelerated obsolescence depending on the technology embodied in an adversary’s military capital and military forces.

Generally, in our analysis, the military capital stocks of the respective countries were calculated using constant-price outlays for military procurement and construction (covering barracks, airfields, communication facilities, and other structures). As with the civilian capital stock estimates referred to earlier, military capital estimates require that we have a benchmark estimate for at least a single year to enable the entire series to be generated. We have used various methods to establish the initial military capital stock figure, generally drawing on the estimates made in our earlier work.\(^4\) We have assumed the same

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\(^4\)See Wolf et al., 1989.
depreciation rate $\delta$ on military capital for each of the five countries, as described in the individual country sections of Chapter Four.\(^5\)

It should be noted that our estimates for 1995 through 2015 assume that each country’s military spending decisions are independent of those of other countries; i.e., reactive effects were not modeled.

\(^5\)The annual depreciation rate, $\delta$, has been arbitrarily set at 10 percent for military equipment acquired prior to 1994, and 8 percent for equipment procured thereafter.