A Long-Run Analysis of the Terrorist Attacks of September 11th:

Reallocations of Resources in the United States Economy*

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April 19, 2002

The terrorist events of September 11th, 2001 have caused and will continue to cause significant reallocations within the United States economy. More resources are going to be allocated to protect Americans from future terrorist attacks. This increase in spending is primarily on homeland defense and on protecting Americans by fighting terrorists outside of the US borders through the use of military forces. This paper analyzes how the reallocations of capital and labor force to the security sector and the change in technological growth will affect the economy. It also focuses on the measurement problem of the GDP, and the relation between the GDP and the welfare of the individuals in the economy. We present our findings to show what impact 9/11 will have on the GDP growth, welfare, and productivity of the United States economy in the long run.

* This paper was written for the undergraduate honors seminar, Department of Economics, University of Michigan. The authors gratefully acknowledge the advice and guidance of Prof. Matthew D. Shapiro.

Introduction

Disasters destroy some of the basic elements of an economy. The loss of human lives and capital reduces the quantity of goods and services produced and consumed. A less predictable effect comes through investments made to rebuild the capital stock and, even more significantly, through longer-term changes in consumer spending—which accounts, in the US, for two-thirds of GDP. America's Council of Economic Advisers studied the economic effects of more than two dozen natural disasters in the country since 1970. They found that none of them, including Hurricane Andrew in 1992, which destroyed assets equivalent to 1% of GDP, had had any discernible effect on growth beyond the quarter in which they occurred.[1] A caveat here, though: part of this welcome outcome may be down to the way GDP is calculated. Destruction of a country's capital stock has no effect on GDP, while rebuilding that stock counts as expenditure.

September 11th, 2001 will be another "calamity day" remembered in the history of United States. Disasters are a long way from being perfect analogies to America's declared "war" against terrorism, of course. Natural disasters are short-term in duration, and geographically limited in impact. Wars are potentially different, in both scale and duration. As a response to the terrorist attacks of September 11th, the United States has responded by drastically increasing spending on two main areas of the economy: homeland defense whose purpose is to keep the US safer by reducing the probability that a terrorist could attack once in the country, and the military whose purpose is to fight against terrorists and the states supporting them. More resources are being allocated on these two areas of the economy than was spent prior to September 11th. In the long-run, these additional resources will have to be paid for by the taxpayers and this will cause a reallocation of spending from the private sector to the government, but it will also cause a reallocation of spending between the non-security sector of the economy and the security sector of the economy.

The reallocation between the private sector and the public sector will result in a loss of welfare to private citizens. Even though, increased military deployment and homeland security expansion will not affect significantly or at most slightly increase the national output in the US, future reallocations will cause households to consume less and therefore leave them with lower welfare level.

In section 2, we will calibrate the US economy prior to September 11th. We'll form a static model that represents the economy's demand and supply sides, and also show the year 2000 allocations of the capital-labor sources among the security and non-security sector.

In section 3, after concluding the static model and having the model reach to the steady-state conditions, we will run the September 11th shocks on our variables. In this section, shocks will be on homeland defense expenditure, and the military deployment outside of the US borders. The shocks differ on scale and duration, but our aim is to find the linear change in different variables of the US economy, but not the magnitude of them.

Finally, in the last section we present our predictions of what impact these reallocations will have on the future of the United States economy, and also the welfare implications of the reallocations. We believe that the individual analysis of all three shocks that we've run will provide not absolute but insightful information about the effects of 9/11 on the US economy.

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[1] Economics Focus, "The Wage of War", Economist, September 2001

THE STATIC MODEL: US ECONOMY PRIOR TO SEPTEMBER 11th

The model that will work the best for our analysis of the long run effects of reallocation of capital and labor in the United States economy is an adapted form of the Solow Growth Model. In particular, we have decided to use Cobb-Douglas production functions for our model because it is the most commonly used form of production function when modeling the U.S. economy. The Cobb-Douglas production shows that there are diminishing marginal returns to capital and labor separately, but there are constant returns to scale by changing capital and labor in the same proportion. The outcomes of diminishing marginal returns and also constant returns to scale are observed in the United States economy, so we believe that the Cobb-Douglas production function best represents the economy. The specific Cobb-Douglas production function for our models follows:

$$Y_i = \overline{A_i} \cdot K^{\alpha_1} \cdot \left[A_i L_i\right]^{(1-\alpha_1)}.$$

In this equation, i is the given sector of the economy, A is the level of labor-augmented technology of the given sector (i), K is the level of the capital stock of the given sector (i), L is the amount of the labor force in the given sector (i), α is the capital's share of output in the given sector (i), Ā is the technology stock level in the given sector (i).

Our model will simplify the United States economy and break it into two main sectors; with the first being the non-security sector and the second being the security sector.

The goods producing sector of the economy will be a virtual catchall sector of the economy. It will include all sectors of the economy that produces goods and services in the United States. This sector will be denoted with a subscript "1" for the different variables that pertain to the non-security sector of the United States economy (i = 1). Private security producing firms and the United States military are not included in the goods producing sector. We use Cobb-Douglas to model the production sector of our economy. We assume that all of the investment that leads to the capital accumulation in the Solow Growth Model will be done by this sector and that the two parts of the security sector can not contribute toward the accumulation of capital. Another assumption that we make in our model is that the non-security sector of the economy is more capital intensive than the security sector.

The security sector of our modeled economy will then be divided further into two sub sectors of security which are: the military security sector, which will be denoted with a subscript M in our model (i = M), and the non-military, or private security sector, which will be denoted with a subscript NM in the model (i = NM). Furthermore, we will assume that the military will act independently from the economy; they will take labor and capital from the rest of the economy but they may not act economically optimally. The non-military portion of the security sector will interact with the goods producing sector of the economy. Labor and capital will adjust freely between the two sectors until the marginal revenue products are equated. The marginal products of capital multiplied by the relative price, which is the real rental rate of capital, will be equated between the production sector and the non-military security sector and the military will take goods without acting optimally, but the marginal products multiplied by the relative prices, and therefore the wages, of all three sectors will be equated to allow the military to hire labor on the open market.

Since we are assuming the U.S. economy is competitive market, the MPL*P is equal to the real wage that is offered and the MPK*P is equal to the real rental price of capital. Therefore, the equation of marginal revenue products needs to hold in our model because if the real wages were different in any of the sectors it would attract all of the labor due to the higher real wage. This is also true for the military sector of the economy; if the military offered a lower real wage than the rest of the economy they could not take labor. The real rental prices of capital must also follow the same principle; we assume that the capital stock is fully mobile among the production and non-military sectors. If the real rental price of capital is unequal between the two sectors then capital will flow from one to the other to make the equation hold. As with the non-security sector of the economy, the production function of the non-military security sector will also be Cobb-Douglas.

We will normalize the price of the production sector to one and all of the prices in the other sectors will be relative to this sector. This makes our total output (Y) have units of output in the non-security sector. Since in our production function, the unit of labor is workers and the unit of capital is dollars, we need to have a variable that makes the units be a measurable term in the final output value. We assume that all of the prices in the year 2000 will be 1, and they will change to keep the marginal revenue products equal in subsequent years. Therefore, all of the national income identities and output values are all in terms of the non-security sector's output.

In our model, there are two separate ways that we define the Gross Domestic Product (GDP) of the United States. The first way that we define GDP is to have the sum of the non-security sector and the military sector outputs equal GDP and consider the output of the non-military sector to be unobservable and unable to add to the total output.

$$Y = P_1 \cdot Y_1 + P_M \cdot Y_M$$

The second way that we define GDP in our model is to look at the output of all three of the sectors and sum them up to get GDP.

$$Y = P_1 \cdot Y_1 + P_M \cdot Y_M + P_{NM} \cdot Y_{NM}$$

Since we have observed that GDP is not necessarily an accurate measure of welfare we will look at welfare measures such as personal consumption levels. We will then look at the differences between the GDP and welfare in the two definitions of GDP.

a. Supply Side of the Static Model

Data Values and Parameters

To begin our model we had to first solve the values of several variables in a static model before we could proceed to the dynamic model and begin shocking it due to the attacks of September 11. We believe that beginning our model in the year 2000 is logical, since the economy had not yet been affected by the attacks and that it was on its way to a steady growth path.

We began our work in determining the static model by searching the Bureau of Economic Analysis (BEA)[2] and the Bureau of Labor Statistics (BLS)[3] to find the variables[4] in our model that are publicly reported and use those values to solve for the others that are not. Some examples of variables that are not reported include: the output

[2] www.bea.gov

[3] www.bls.gov

[4] All the variables we use in our model and their brief definitions are in Appendix A

of the non-military security sector and the capital that is used by the same sector. The table below gives the values of variables that were reported and that we used to begin solving our model for the year 2000. Variables that we used in the model that are publicly reported are; Total Labor in the economy (L), labor in all three sectors (non-security (L_1), military (L_M), and non-military security (L_{NM})), the total capital stock of the economy (K), total output (Y), and the output of the military (Y_M).

K	26,9 trillion
L	139,8 million
L1	134,6 million
LNM	3 million
LM	2 million
Y	10,2 trillion
YM	137,9 billion

Along with using values that are reported publicly, we needed to parameterize the capital share of output (α) for the economy in order to solve for our model in the year 2000. Following are the values that we parameterized for the alphas for our production functions:

$$\alpha_{\Theta} \ \Xi \ \eta\zeta\Pi$$

$$\alpha_{\phi\Phi} \ \Xi \ \eta\zeta\Theta$$

For the non-security sector of the economy we decided to use one third. The reasoning for this selection is that it is a commonly used value for the United States economy according to many economic sources, including Gregory Mankiw[5]. For the non-military security sector we chose to use the value of one tenth. According to the Department of Commerce report on sectors in the US economy, the non-military security sector is 30% as capital intensive as the rest of the economy. It is certainly reasonable to reach this fact, because non-military security sector requires more workers than any other

[5] Mankiw, Gregory 2000, Macroeconomics 4th edition

sector; contribution of capital and technology is not as heavily important as labor force's role. Therefore, we parameterize $\alpha_{\phi\Phi}$ be equal to one tenth.

<u>Supply Side Solution</u>

To solve the static production model for the year 2000 we used all of the parameters and values that we have found above to find the values of the other variables that we will need to use to eventually make our model a dynamic one. To determine the values for our model that cannot be found in economic literature, we used several equations that we have from the Cobb-Douglas production function. The first value that we found was relatively simple; since we assume that the total output is equal to the sum of output of all three sectors, and we know the values of total output and output of the military sector, we subtracted the output of the military from total output and got the value of non-security sector output plus non-military security output as follows:

$$P_1 \cdot Y_1 + P_{NM} \cdot Y_{NM} = Y - P_M \cdot Y_M = 10{,}236{,}900{,}000{,}000 - 137{,}900{,}000{,}000$$

$$P_1 \cdot Y_1 + P_{NM} \cdot Y_{NM} = 9{,}861{,}500{,}000{,}000\,.$$

In our model, the output of the military sector and military expenditure done by the government do not have the same value. The military sector takes a proportion of the non-security sector's output as an investment and this value depreciates completely in the year, or with the factor of 100%. Therefore, there is no capital stock for the military sector, but only yearly capital flow from the production sector. The only tangible output produced by the military sector is the wages that it pays its workers, which contributes to the total output under Y_M.

Now that we have the value of the output in the non-security sector of the economy plus the output in the non-military security sector (Y_1+Y_{NM}) and know all of the labor numbers, we can solve for the individual values of the output of the production and the non-military security sector of the economy. To solve for the output of the non-military security sector we had to find the marginal product of labor (MPL) for the two sectors from the production function. To calculate the MPL for each sector we took the partial derivative of Y with respect to L:

$$MPL_i = \frac{\partial Y_i}{\partial L_i}.$$

The assumption that allowed us to find the value of (Y_{NM}) was that the $MPL_1*P_1=MPL_{NM}*P_{NM}$, in other words wages, and the MPL equations that we used in our model are below.

$$MPL_i = \overline{A}_i \cdot (1-\alpha_i)\cdot\left[\frac{K_i}{L_i}\right]^{\alpha_I} \cdot A_i^{(1-\alpha_i)} = (1-\alpha_i)\cdot\frac{Y_i}{L_i}.$$

Equating the marginal revenue products in our economy will allow for the free flow of labor between the sectors. We can then rearrange the MPL equation equations to get the following equation that we will use to find the value of output in the non-military security sector.

$$\frac{L_1}{L_{NM}} = \frac{(1-\alpha_1)}{(1-\alpha_{NM})}\cdot\frac{Y_1}{Y_{NM}}\cdot\frac{P_1}{P_{NM}}$$

Since we have, or found, all of the variables in this equation except for individual Y_{NM} and Y_1 values, we can use their ratio (Y_1/Y_{NM}) to solve for each of them, separately. The sum of two sector's output value and their ratio give us the values of Y_1=9.9 trillion dollars and Y_{NM}=164 billion dollars.

At this point of our static model solution, we know all of the values for capital's share of output α_i, labor values L_i, and output values Y_i for our model. The next step is to solve for the capital values. We already know the total capital stock of the economy (K=$26.7 trillion) from the reported value by the BEA that is equal to the sum of capital stock of the non-security and non-military security sectors.

$$K = K_1 + K_{NM}$$

In order to divide the capital to the two remaining sectors we need to lean on our assumption that the real rental prices of the capital are equal and that capital flows accordingly to make that happen. The following equation is the MPK of both of the remaining sectors:

$$MPK_i = \overline{A}_i \cdot \alpha_i \cdot \left[\frac{K_i}{L_i}\right]^{(\alpha_i - 1)} \cdot A_i^{(1-\alpha_i)} = \alpha_i \cdot \frac{Y_i}{K_i} \; .$$

Assuming that the real rental prices are equal, we can use the far right hand side of the above equation and rearrange it to get the ratio of capital between the production sector and the non-military security sector. The ratio is as follows:

$$\frac{K_1}{K_{NM}} = \frac{\alpha_1}{\alpha_{NM}} \cdot \frac{Y_1}{Y_{NM}} \cdot \frac{P_1}{P_{NM}} .$$

Substituting the values that are already known we find that the ratio of capital in the production sector to the capital in the non-military security sector (K_1/K_{NM}) is equal to 201.4. This value again is reasonable because of the sheer size of the two sectors, and rational assumption that we have made about our model that the non-security sector is more capital intensive than the non-military security sector. Therefore we now can divide up the total capital stock to the sectors (1) and (NM). We found that the value of capital in the non-security sector of $23.9 trillion and the value of capital of the non-military security sector of $131.9 billion will allow for the real rental prices to equate.

In our production functions, the value of the labor-augmented technology is considered to contribute toward the effectiveness of the labor of the given sector. So, in a sense the value of (A_i) is a measure of effective labor in the given sector of the economy. We will assume that this value starts initially with the value of 1 in all sectors, so that we are setting 2000 as a base year for the relative value of effective labor. In addition, there is a technology stock variable that also contributes to the effectiveness of capital in the production function, in our model we will denote this variable as ($\bar{A}$). This variable is the residual of the production function; it is the remaining factor, which emerges after we have accounted for the determinants of the output such as capital, labor, and the labor-augmented technology.

b. Demand Side of the Static Model

In the demand side of our model we use the standard macroeconomic theory that total output equals the sum of consumption, investment, and government spending.

$$Y = C + I + G$$

We also assume that our modeled economy is closed to foreign trade, unlike the conventional model. It's not an unrealistic assumption since the ratio of total import-export to the GDP in the US economy is close to 10%. So, the net exports value is added back to the total output value of the economy because the US has run a trade deficit in the year 2000. In the separate components of production that we have, the demand is defined differently than it is for the total economy. The demand of goods in the non-security sector of the economy is the sum of consumption of the non-security sector output, the investment in the non-security sector, and the investment of government for military product.

$$Y_1 = C_1 + I_1 + I_M$$

For the non-military sector of the economy the output must only equal the consumption of that sector, because we assumed this sector does not contribute to the accumulation of the capital stock.

$$Y_{NM} = C_{NM} = \$164,4 \text{ billion}$$

Finally, in the military sector of the economy demand exceeds the supply because of the following assumption that we made: the investment in military products are entirely used, or depreciated in the year that the investment is made. So, the only tangible output by the military sector is the wages that is paid to its workers that are spent on consumption in the other sectors. Therefore the supply for and output of the military sector is defined as:

$$Y_M = G_L = \$137,9 \text{ billion}$$

And the demand of the military sector is defined as:

$$G = G_L + I_M$$

$$G = \$137,9 \text{ billion} + \$237,5 \text{ billion} = \$375,4 \text{ billion}$$

We found the values of GDP (Y), personal consumption expenditures, gross private domestic investment, and government expenditure and gross government investment from the Bureau of Economic Analysis (BEA). The values of these variables, that we found, are in the following table:

GDP	$10,2 trillion
Personal consumption expenditures	$6,7 trillion
Gross private domestic investment	$1,7 trillion
Government consumption expenditures	$318,3 billion
Gross government investment	$1,4 trillion

The non-military government investment is added back to the private domestic investment, which made up total investment (I) in the economy, and non-military expenditure of the government is added back to the personal consumption expenditures, which made up the total consumption (C) in our model. The values of total consumption, total investment (I), military expenditure on wages (G_L), and military investment (I_M) on production are in the following table.

Total Consumption	7,829,200,000,000

Total Investment	2,032,300,000,000
G_L	137,900,000,000
I_M	375,400,000,000

So, the value of consumption and investment will be higher in our model than in the actual economy. We believe that this is a safe assumption and there are examples, to show that this accurate. An example of government spending that could be considered private consumption takes place in universities: professors' wages in state colleges are considered to be government spending while wages in private colleges are considered personal consumption expenditure. However, they are both part of the GDP, they only are counted in different categories. In our model, we combined non-military government spending with personal consumption expenditure under the total consumption category.

We calculated the national savings rate using the equation that follows.

$$s = \frac{I}{(Y - G)} = 21\%$$

Furthermore, in our model we will assume that all of the investment that contributes to capital accumulation in the dynamic Solow model is done by the non-security sector.

$$I = I_1$$

In order to divide total consumption into consumption in the sectors we used the following equations for the production sector and the non-military sector respectively.

$$C = C_1 + C_{NM}$$

$$C_1 = (1 - s) \cdot \lambda_c \cdot (Y - G)$$

$$C_{NM} = (1 - s) \cdot (1 - \lambda_c) \cdot (Y - G)$$

The definition of the value of lambda is the share of total consumption that is done by the non-security sector. All of the leftover consumption belongs to the non-military security sector. For the year 2000 we found that the value of lambda to equal 98%. Therefore, the level of consumption in the production sector (C_1) is \$7.6 trillion and for the non-military sector (C_{NM}), it is \$164.4 billion.

THE STEADY STATE MODEL

After solving for the static values of our variables for our model in the year 2000, we can now allow for our model to grow and solve for the steady state condition, which will allow for us to shock the model and analyze the attacks of September 11th. Again, we are using the Solow growth model to replicate the United States economy. The Solow growth model is designed to show how capital stock, labor force, and technological advancement interact with each other in the economy and lead to economic growth. Our goal is to examine how the demand and supply for goods and services determine the accumulation of capital. The Solow capital accumulation theory says that there are two forces that determine the level of capital in subsequent years, which are: investment and depreciation of the existing capital stock. Investment increases the stock of capital in the following year while the depreciation of existing capital leads to a fall in the capital stock. Thus, the capital accumulation equation that we use in our model follows:

$$K_{t+1} = K_t(1-\delta) + s(Y-G)$$

The growth in capital in the economy is only one of three sources of growth that contributes to the growth of the overall economy. In our model the other two sources of economic growth are: an increase in the labor force and the growth in the labor-augmented technology. Almost all models of growth and capital accumulation, of both endogenous and exogenous types, confront this fact using a special assumption on the direction of technical change: technical progress is assumed to be purely labor augmenting.

More specifically, consider our general production function of the form $Y_i = f(\bar{A}_i K_i, A_i L_i)$ where K is capital and L is the labor force. The assumption of labor-augmenting technical change implies that new technologies only increase Ai, and do not affect Ā, or in other words technical progress shifts the isoquants in a manner parallel to the labor axis.[6]

In our model the increase in L is 1.2% per year (n). We arrived at this value by averaging the value of the increase in L for the ten years prior to 2000, as reported by the BLS. The value of the growth rate in the labor augmenting technological progress, or A, is 1.6% per year (g) according to the report, The Budget and Economic Outlook: Fiscal Years 2003-2012.

Now that we know how all of the variables in our production functions are growing, we can solve for the steady state condition. In the steady state condition the change in capital stock per effective labor (K/AL), which is denoted as k, is equal to the investment that is done by the economy minus the break-even level of investment.

$$\Delta k = s \cdot (Y - G) - (\delta + n + g) * k$$

Using this equation we are able to solve for the depreciation rate for our model of the US economy, which we found to equal 0.0475 (δ). The reason that the capital accumulation identity is correctly expressed as an aggregative relationship despite the sectoral structure of the model is because capital is perfectly mobile.

[6] Acemoglu, Daron, 2000, Labor – and the Capital – Augmenting Technical Change

The next thing that we had to do was to allocate the capital and labor figures among the different sectors. The military sector takes its capital as investment from the goods the non-security sector produces every year and it is depreciated by the factor of 100%. As we have stated before in the static solution of the model the government, or military, does not have economic concerns and does not necessarily act economically optimally based on the equation of marginal revenue products. We also assume that the increase in military labor mirrors that of the increase in overall labor supply. The residual labor force and capital stock are then distributed to the production and non-military sectors based on the principle of equal marginal revenue products.

$$MPL_1 \cdot P_1 = MPL_{NM} \cdot P_{NM}$$

and

$$MPK_1 \cdot P_1 = MPK_{NM} \cdot P_{NM}$$

In order to equate the marginal revenue products we proceed in solving the following series of equations.

$$k_i = \frac{K_i}{L_i}$$

and

$$\frac{k_1}{k_{NM}} = \frac{\alpha_1}{\alpha_{NM}} \cdot \frac{(1-\alpha_{NM})}{(1-\alpha_1)} = 4.5$$

and

$$k_{NM} = \left[\frac{\overline{A}_1 \cdot P_1 \cdot \alpha_1 \cdot A_1^{(1-\alpha_1)}}{\overline{A}_{NM} \cdot P_{NM} \cdot \alpha_{NM} \cdot A_{NM}^{(1-\alpha_{NM})}} \right]^{\frac{1}{(\alpha_{NM}-\alpha_1)}}$$

and

$$K = (k_1 \cdot L_1) + [k_{NM} \cdot (L - L_1)] \qquad L_1 = \frac{K - (k_{NM} \cdot L_1)}{k_1 - k_{NM}}$$

and

$$L = \frac{K_1}{k_1} + \frac{K - K_1}{k_{NM}} \qquad K_1 = \frac{k_{NM} \cdot (k_1 \cdot L - K)}{k_{NM} - k_1}$$

The marginal product of labor of all three sectors of our simulated economy will be equated allowing for the addition of labor into the military sector. We also assume that the relative prices in the sectors are all equal in the first year of our model, 2000 ($P_1 = P_{NM} = P_M$). The relative price of the non-military sector (P_{NM}) will change, while the prices of the other two sectors will remain equal to 1 (P_M and P_1) to keep the rental rates and wages equal in the years to follow.

The values for the marginal revenue products, which we obtained from the calculations, follow different growth patterns. The rental price of capital converges to about $0.11 and the marginal revenue product of labor will not converge, but it will increase with the rate of labor-augmented technology growth of 1.6%. These findings are consistent with Acemoglu's assumptions:

> *Over the past hundred and fifty years of growth, the prices of the two key factors, labor and capital, have behaved very differently. While the wage rate, the rental price of labor, has increased at a rapid rate, the rental price of capital has remained approximately constant. For example both the interest rate and the capital share of GDP have been approximately constant in the US over the past one hundred years (see, for example, Jorgensen, Gollop, and Fraumeni, 1987, or the Economic Report of the President, 1998).*

In our model the steady state value of the growth rate in capital and output of the economy is approximately 2.8% per year, which matches what the Solow growth model predicts for the growth rate of the total output and capital (n+g).

The demand side of our economy also converges to steady state growth rates. The total consumption, consumption of the production, and the non-military sectors in our economy grow at a rate of 2.8% as well. As for the total government expenditure, it also grows at the rate of 2.8%, with the wages paid to employees growing with the rate (n) of 1.2% and the investment taken out of the production sector growing at 2.8%. Investment that contributes to capital accumulation in our economy is growing at the rate of 2.8%. This happens because investment contributes to capital accumulation, and the growth rates therefore should be the same.

In the steady state, the supply side of the economy equates with the demand side. In our modeled economy we assume that the demand (consumers) and the supply (production) interact with each other and are always in equilibrium. In order for us to do this we must allow for λ to adjust freely and act as an intermediary variable between the two sides of the economy.

In the steady state model of the economy, the relative sizes of outputs, capital stocks, and labor force are approximately the same as the relative sizes in the year 2000. For example, in the steady state, production output is larger than the output of the non-military security sector, as it is in the year 2000.

SHOCKING THE STEADY STATE MODEL

Now that the steady state conditions of our modeled economy have been solved for, we can begin to shock it to simulate the possible effects of the terrorist attacks on September 11th. Our shocks will occur after every variable in our economy has reached its steady state growth path. We will perform two different shocks to the economy separately: the first shock increasing the government spending on military and the second shock increasing consumption in the non-military security sector. For the shocks that increase the government spending on the military, we will perform the shock with two different time horizons; one where the spending is increased for only one year and one where it is increased for four.

Military Shock

In the first shock that we perform, we assume that the government decides to increase its amount of labor force by 50%. Meanwhile, it also demands 50% more investment from the production sector such as new aircrafts, missiles, and other goods. After the labor market is clear and the new real wages are determined by the change in the demand for labor, the total government spending on the military will also increase approximately with the same rate, 50%.

We also run a second shock on the military spending by the government, but the length and magnitude differed. The shock will last for four years, rather than one, and the magnitude of the shock to investment demanded from the production sector and increase to the labor force will be 15% each of the four years. The reason for shocking for an extended time period is to show the effects if the Bush administration decides to wage a longer term fight against terrorism.

Non-military Security Sector Shock

The final shock that we will run through our dynamic model is a shock to the amount of non-military security that is demanded. Under this shock, we will expect that the demand of consumers for private security will increase by about 6 - 7 percentage points. In our model, this will be modeled by a decrease in λ. Therefore, the production side of the non-military security sector will respond to the increase in demand by increasing its labor force and its capital stock.

Before we begin the analysis of our shocks to our model, we want to discuss the magnitudes of our shocks. In our analysis, we will look at percent changes relative to the steady state growth rates of our variables. So, if we increase or decrease the magnitudes of our shocks it will change the nominal values of our variables, but the general path of our findings will remain the same. This is because our shocks will have a linear effect on the nominal values of our variables.

ANALYSIS OF SEPTEMBER 11TH ATTACKS [7]

To analyze the effect of the terrorist attacks we will use comparative statics to look at the changes in our indicator variables, such as the growth rate in total output (%ΔY), the non-security sector's output (%ΔY_1), the output of the non-military security sector (%ΔY_{NM}), the level of consumption in the production (C_1) and the non-military (C_{NM}) sectors, the level of investment in production goods done by the government for the military sector (I_M), and the level of spending by the military on labor, in other words the output of the military sector (G_L=Y_M). We want to compare the effects of the shocks that we have described above to the levels of these indicator variables in their steady state conditions.

The first shock that we are going to analyze is the four-year increase in military spending by the government in which government spending on labor (G_L) and capital flow (I_M) is increased by 15% per year for four years. After concluding the shock, labor (G_L) and the investment (I_M) are growing with the same level of the no shock model, but the nominal levels are higher. This shock to the military's spending on labor and capital flow will cause the output of the military sector to also increase. The shock will raise the level of the military output, and will have no effect on the rate in which it grows after the shock is complete. Output of the military sector will increase by approximately 15% every year for the four years of the shock. This causes the percent growth rate of total output to slow down by .2-.3 of a percentage point, during the four years of the shock. In the fifth year after the shock, the growth rate jumps up .2 of a percentage point, which is still below the no shock level of 2.8% growth, and begins to converge to the steady state growth rate (Figure. 1c). The impact of the military shock on the consumption is greater

[7] For a graphical interpretation of the analysis, refer to the appendix B.

than the impact on GDP. The growth of total consumption slows to a minimum growth rate .6 percentage point below the pre-shock, or steady state level (Figure. 7c)

The growth rate of the non-security sector increases initially due to the military shock. The magnitude of the increase is .1 of a percentage point in the first year. In the second year the increase in the growth rate is less than the previous year, but still above the no shock rate. Starting with the third year post shock, the growth rate is falling below the no shock rate by .3 of a percentage point. In the subsequent years after the shock is completely finished the growth rate of the production sector's output converges back to the steady state (Figure. 3c).

Contrary to the growth rate of the non-security sector, the rate of growth in the non-military security sector decreases continuously during the four years of the military shock. The growth falls 1.4 percentage points for the four years. After the shock is over, the growth rate jumps in the fifth year by 2.5 percentage points from the level during the shock and reaches to 3.6% growth level. In the following years, this slows and the rate converges once again with the steady state (Figure. 4c).

We will now discuss the reasons for the changes in the output due to the shocks. First of all, the increase in the output of the military sector is caused by the increase in military personnel hired by the government. Meanwhile, they also increase their spending on military goods produced by the non-security sector such as aircrafts, missiles, weapons etc.

To match with the increase in demand coming from the military sector, the military goods producing firms, such as Lockheed, Boeing, and Raytheon, in the non-security sector will increase their production capacity. For these firms to increase their production, they will have to increase their capital stocks and labor force. This will lead to an increase in the growth of the non-security sector for the years that the shock is effective.

The increase in the labor that is reallocated to the military and production sectors, and the capital that is allocated to the non-security sector leaves the non-military security sector with less labor and capital relative to the no shock levels. Hence, the growth rate of the private security sector will relatively slow during the four years of military increase.

Combining all of the effects of the military shock on the separate sectors of the economy we arrive at the change in the growth rate of GDP. Even though outputs of the military and non-security sectors rose relative to the no shock levels, the sum of the increase in both of the sectors is less than the decrease in the non-military sector. We think that the reason for that is the military sector and the portion of the non-security sector that produces military goods is a small segment of the total economy. So, the increase in the growth of the production sector is very small and the decrease in the private security growth is large relatively, leading to a slight decrease in the growth of GDP.

After increasing the spending on the military for four years, government decides to return to its previous spending levels. This will lead to a recovery to the steady state conditions for the growth rates in the sectors. However, the level of output and investment of the military will continue to grow with the steady state rate, yet at a higher level.

After four years, due to the return to the previous level of demand by the government for military goods, the military goods producing portion of the non-security sector will cut down its output. For instance, firms such as Lockheed and Boeing will layoff workers and use less capital and this will lead to an overall decrease in the growth rate of this sector. Eventually, the steady state rate will be reached.

For the non-military security sector, after four years, capital and labor will return to the sector from the non-security sector. This is going to lead to a jump in the growth rate of the output of this sector for the fifth year post shock, while leading to a sharp decrease for the production sector, but both of the sector's growth rate will eventually converge on the steady state. The recovery in the total output growth will start immediately by returning to the pre-shock level right after the four-year shock.

For the one-year military shock the reasoning for the changes in the growth rates and levels of output remain the same as in the four-year shock model. However, the magnitudes of the impacts of the shock will differ. For instance, contrary to the four year shock, the decrease in the growth rate of the non-military sector will be much more severe, even leading to a shrinking of the output. A 50% increase in the military spending for one year will lead to a negative 1.9% growth rate in the non-military security sector (Figure. 4d). In the meantime, the growth rate for the non-security sector will increase by .3 of a percentage point to a 3.1% level (Figure. 3d), and the growth rate of the GDP will decrease by .5 of a percentage point to the level of 2.3% growth (Figure. 1d)

The second shock that we ran on our modeled economy was to shock the amount of demand for consumption of the non-military security sector. We believe that due to the terrorist attacks of September 11th, the American people and the government increased their demands for a higher level of security for our nation. For example, the lines at security checkpoints in airports are considerably longer than pre-September 11th, airports hired more security personnel and started to use more equipment to ensure safety. In the mean time, right after the attacks, many sources announced that the sale of gasmasks, home security devices, and other forms of personal protection rose immensely.

In our model, we parameterize that the demand for the private security will increase by around 30%. To respond to this increase from the demand side of the economy, the sector will hire 30% more labor and rent 45% more capital. This will result in an increase in the level of non-military security output of approximately 35%. The year that the shock is made, the growth rate of the sector is going to increase by 32 percentage points and then return to its previous growth path the following year (Figure. 4b).

For the non-security sector, an opposite trend will be seen. The year that the shock is made to the non-military sector, the non-security sector is shrinking. The growth rate of the sector is decreasing by 7 percentage points to the level of negative 4%. As it is seen for the non-military security sector, the growth rate is recovering to its steady state level in the year after the shock (Figure 3b).

For the military sector, during the shock, the level of investment in goods from the non-security sector is decreasing by 7% (Figure. 5b). While, the output of the sector, or total wages paid to the workers, increases by 3% (Figure. 6b).

Summing together all of the changes to the outputs of the different sectors, we arrive at the change in GDP. The growth rate of the total output of the economy is expected to decrease by .1 of a percentage point. As it happens for the sectors, the growth rate of GDP returns to its steady state level in the following year (Figure. 1b).

We now want to discuss the reasons for the changes in output of the different sectors that result from the shock to the demand of the non-military sector. Due to the shock, the non-military sector is shrinking because labor and capital shifts to the non-military sector are coming directly from this sector. Since there is less capital and labor, output in the non-security sector must decrease. After the shock, the growth rate returns to the steady state because the sector will adjust to the new levels of capital and labor.

To meet the increase in demand for the non-military security, we assume that since this sector is labor intensive, the magnitude of the response in the amount of labor that is required should be the same as the increase in demand (30%). Due to our assumptions that labor and capital markets are clear, mobile, and respond instantaneously, capital in the non-security sector and the private security sector adjust themselves according to the equation of real rental price of capital (45% increase in NM). These factors are the reason that the growth of output in the non-military security sector increases for the year of the shock. It then recovers back to the steady state in the following year because the sector will adjust to the higher levels of its inputs.

For the military sector the changes affecting this sector arise due to the interactions between the other two sectors. The level of the investment in this sector is decreasing because an overall decrease is seen in the non-security sector's output. Due to the fact that investment of the military sector is part of the non-security sector's output, the decrease will also be felt by the military. As we have pointed out before, the government decides to hire a certain amount of labor without acting economically optimally. Since the number of workers does not change in the military sector, the only change that affects the output, or total wages, of the military is the change to the real wages in the economy. As the Heckscher-Ohlin-Samuelson two-factor model proves, an amount of labor increase in a sector that is relatively higher in labor intensity will bid up the real wage in the total economy. For example, after Mexico and the US opened their borders, real wages in Mexico increased. The reason for that is the factors used to be immobile and the Mexican economy was much less capital intensive, or had higher labor intensity. The same result can be seen in our model. After the non-military sector, which is relatively higher labor intensive, demands more labor from the economy, real wages will increase. Since the government is not changing their labor level, due to the change in real wage the level of total expenditure on labor will increase.

So far, we have looked at the effects of the shocks on the outputs of the sectors and the total economy. Even though, the growth and level of output are important indicators for the well being of the economy, another indicator that may work better is the level of consumption, which shows the level of welfare of individuals. In this model, we assume that the feeling of individual safety is a measured tangible output that is not compatible with the modern measurement theory of economics. Continuing with the notion that security cannot be measured[8], in this sense, the best indicator that we have in our model of welfare is the level of consumption of production goods (C_1). We assume this because the increase in the military output and non-military consumption level changes in our model are made to return the individuals' feeling of security to the pre-September 11th levels. An example of this is the current condition with the airline industry. After the terrorist attacks, airports increased their level of security to give the consumers the same feeling of safety of pre-September 11th level, but individuals were reluctant to fly, so the level of utility of the security remained the same as pre-shock, but the individuals utility level of tangible goods and services becomes relatively lower.

However, if the output of the non-military security sector can be measured as the case with the security sector, what our model shows is that the best indicator of welfare in the economy, contrary to the unmeasured security sector model, is the total level of

[8] $Y = P_1 \cdot Y_1 + P_M \cdot Y_M$

consumption (C). Even though, from the psychological perspective, the feeling of safety has not changed with the increase in the level of security, from the economic sense, the utility of consuming non-military security output increased. This logic leans on the common assumption that individuals' utility functions are monotonic and that the higher the levels of consumption will result in a higher level of utility. So, despite the feeling that our welfare is lower due to the attacks, utility from consumption is just transferred from one sector to the other

In all of the three shocks that we run on our modeled economy, the growth rate of the consumption of the production sector are decreasing. In the non-military security demand shock, the level of C_1 is decreasing, which means the growth rate for the period of the shock is negative (-6.4%) (Figure. 8b). This is consistent with the example of the airline industry that we mentioned above. However, the level of total consumption of the economy ($C=C_1+C_{NM}$) will not change significantly (.09 of a percentage point) (Figure 7.b). This also shows that if we could measure non-military security consumption levels then we would not see any decrease in our welfare level.

The values of the level of consumption in the non-military security sector will increase due to the shock in the demand of this sector. The year that the shock is made, the consumption is going to increase by 35% and then return to its previous growth path the following year (Figure. 9b). This reallocation of the consumption levels will result in a change of the percent of total consumption done in each of the two sectors, production and non-military security. Our value of λ, or percent of total consumption done by the production sector, will fall by 5 percentage points.

For both of our military shocks, one-year and four-year, the increase on military spending will lead to an increase in the government expenditures. However, the affect of higher military spending will be severe on the total consumption level and the growth. The reason for that is the national gross domestic product of the US economy, in our model, is divided among three elements: investment, government expenditure, and consumption. Due to the higher government expenditure, individuals will get a lesser share from the economy. The total consumption after the shocks will grow by 1.1%, which is lower than the no shock condition of 2.8% (Figure. 7d). As the numbers show, the allocation of the sources from other sectors to the military is not affecting the level or the growth rate of GDP significantly, but decreasing the consumption levels of people. In other words, our nation's welfare will be lower due to the military buildup.

To analyze the productivity of our economy, we will look at the value of output per worker ratio (Y/L). In all of the shocks that we ran on our modeled economy, productivity levels decreased in the years of the shocks. Shocking the military sector of the economy caused the growth rate of productivity to decrease by .4 of a percentage point in the one-year shock and by .3 of a percentage point in the fourth year of the four-year shock. The shock to the demand of the non-military security sector will cause productivity to fall even less than the military shock; it will fall by less than .1 of a percentage point (Figure 2).

CONCLUSION

There will be long run consequences due to the attacks on the United States of September 11th. It will show its impact on many aspects of Americans' lives; American politics, sense of security, its role in the international arena will drastically change. American economy is another field that will feel the inevitable consequences of September 11th. Attacks against the World Trade Center and Pentagon caused huge capital and labor force losses, negatively affected consumer confidence and preferences, and increased the government expenditure on homeland and foreign security. Even though, all the changes mentioned above are important on Americans' lives, they're all influential in the short-run. In this paper, we've tried to analyze the long-run effects of September 11th attacks.

Announced government expenditure rises by Bush administration on two main areas, homeland security and military deployment outside of the US borders, and consumer demand for private security goods will cause resource allocations within the US economy. Capital and labor reallocations from other sectors to the sectors related to the security will change the productivity, production mode, and the national income of the US in the next decades.

In this paper, we've, first, formed the static model of the US economy based on two-sector model and then had the economy reach the steady-state conditions. This would give us the opportunity to analyze and compare the post-September 11th shock conditions of the US economy to the pre-shock levels. Throughout this paper, we've mainly tried to find answer to how these attacks would affect the output (GDP) and the welfare level of the US economy.

The first two shocks (one and four year military shocks) we've run on the model would increase the government spending on military. Our findings show that growth rate of GDP will at most slightly decrease, while the consumption level of households will significantly fall after the shocks.

The third shock, which will increase the production of non-military security sector, will be due to the increased demand for private security by households. Impact of this shock on GDP and consumption will follow the same pattern the shocks we've previously introduced did: Growth rate of national output will slightly decline while decrease in consumption will be more significant.

There's an important point that should be made for the sake of research. When this research was made, increases in government expenditure on military and consumer demand for security goods were expected, but their amounts were not known. We parameterized the scale and duration of the impact of 9/11 on those three shocks. Therefore, changes in GDP growth rate and consumption level, which appeared to be significant or insignificant, might be more or less significant depending on the scale and duration of the resource allocations.

Another important aspect in this paper that should be pointed out is the measurement problem of GDP and the definition of welfare. It's apparent from our research that the level of consumption will be lower in the post-September 11th US. However, only looking at the consumption level of consumers leaves out an important but much harder to measure aspect of the utility of consumers. This is illustrated in the following fictitious example. Two identical people are going to an airport to take a flight. The only difference in the two people is that the first person lives in the United States post September 11th with a huge increase in airport security. The second person lives in the United States post September 11th, but in his case the United States decided that increasing airport security would be too costly and left the old system and regulations in place. It is obvious that the first person will feel more secure with the increased security whereas the second person will feel much more vulnerable to a terrorist act. The problem is that there is no way to accurately measure the feeling of security and safety the first person has and to add it to their utility function. Thus, it is apparent that the utility function of consumers includes both consumption and the intangible feeling of security or well-being. This wedge, or difference between measured output and utility, signifies a significant shortcoming of using GDP as the primary economic indicator since GDP is leaving out this important piece of information.

In this paper, we see this shortcoming very clearly. In the measurement of GDP, we assumed that we could measure the output of non-military security sectors as a tangible output (sense of security), while we didn't include it in the consumption level of households (C_1). That's the reason why the fall in GDP is less likely than the fall in the consumption level. If we also assume that people can consume security and increase their "sense of security utility", then we add up C_{NM} and C_1 to find the total level of consumption, and the decrease in welfare will be very less in this case than otherwise.

Effects of September 11th shocks on the US economy will not only be about the scale of impact of them on the economy but also will also raise important questions about the definitions in the standard macroeconomic theory.

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Appendix A

VARIABLES

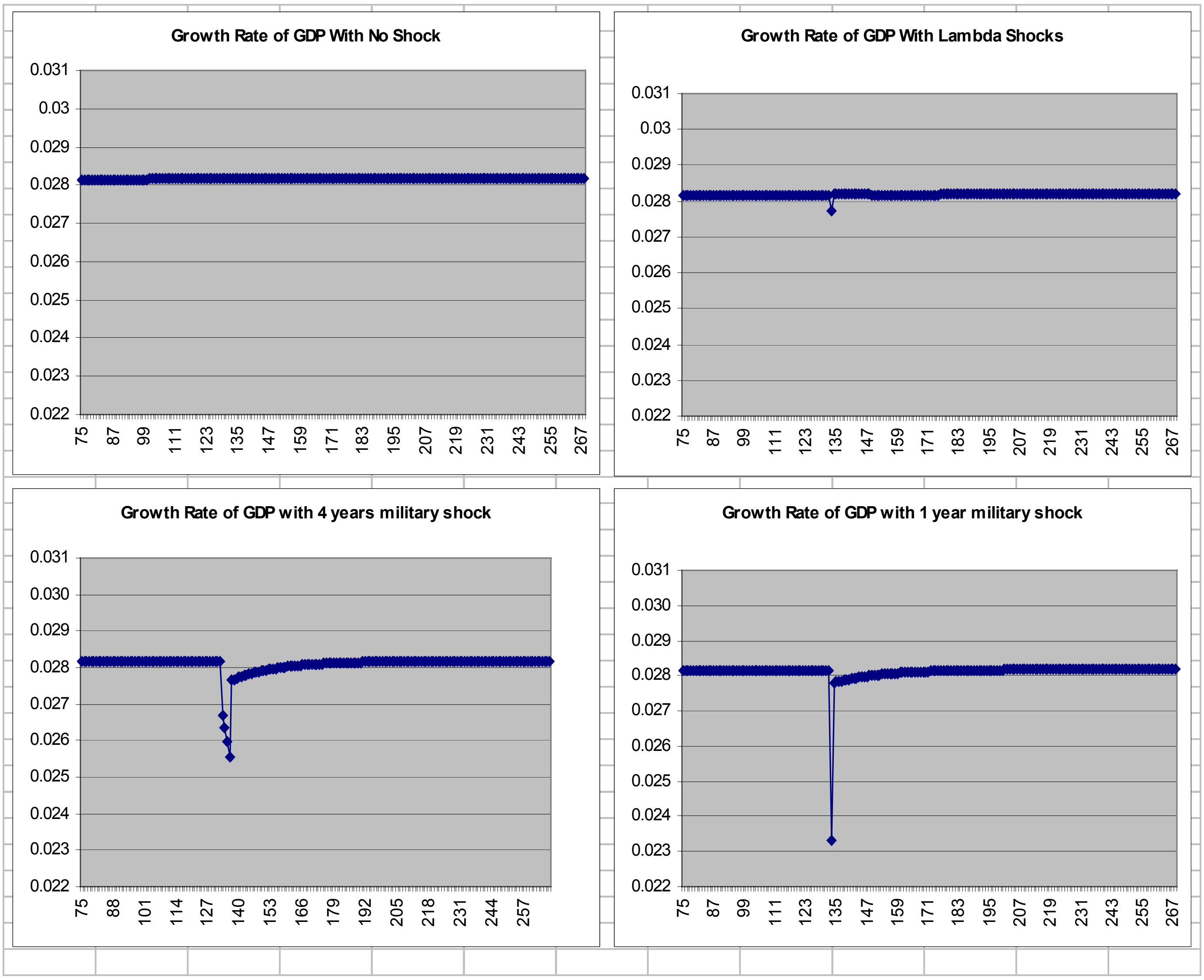
Following are the variables that we use in our model, along with a brief definition of what each variable represents in our modeled economy:

Variable	Definition
Y	*Total Output / GDP*
Y_1	*Output of the production sector*
Y_M	*Output of the military sector*
Y_{NM}	*Output of the non-military security sector*
L	*Total Labor*
L_1	*Labor of the production sector*
L_M	*Labor of the military sector*
L_{NM}	*Labor of the non-military security sector*
K	*Total Capital*
K_1	*Capital of the production sector*
K_{NM}	*Capital of the non-military security sector*
A_1	*Labor-augmented Technology Parameter of the production sector*
A_{NM}	*Labor-augmented Technology Parameter of the non-military security sector*
$\bar{A}_1$	*Technology stock level of the production sector*
$\bar{A}_{NM}$	*Technology stock level of the non-military security sector*
α_1	*Capital's share of output of the production sector*
α_{NM}	*Capitals share of output of the non-military security sector*
C	*Total Consumption*
C_1	*Consumption of the production sector*
C_{NM}	*Consumption of the non-military security sector*
s	*National Savings Rate*
I	*Total Investment*
I_1	*Investment of the production sector*
G_L	*Government expenditure on labor for the military*
I_M	*Investment of the military sector*
λc	*Ratio of Consumption to total non-military Consumption (C1/(C1+Cnm))*
P_i	*Price levels of the sectors*

Appendix B

Figure 1

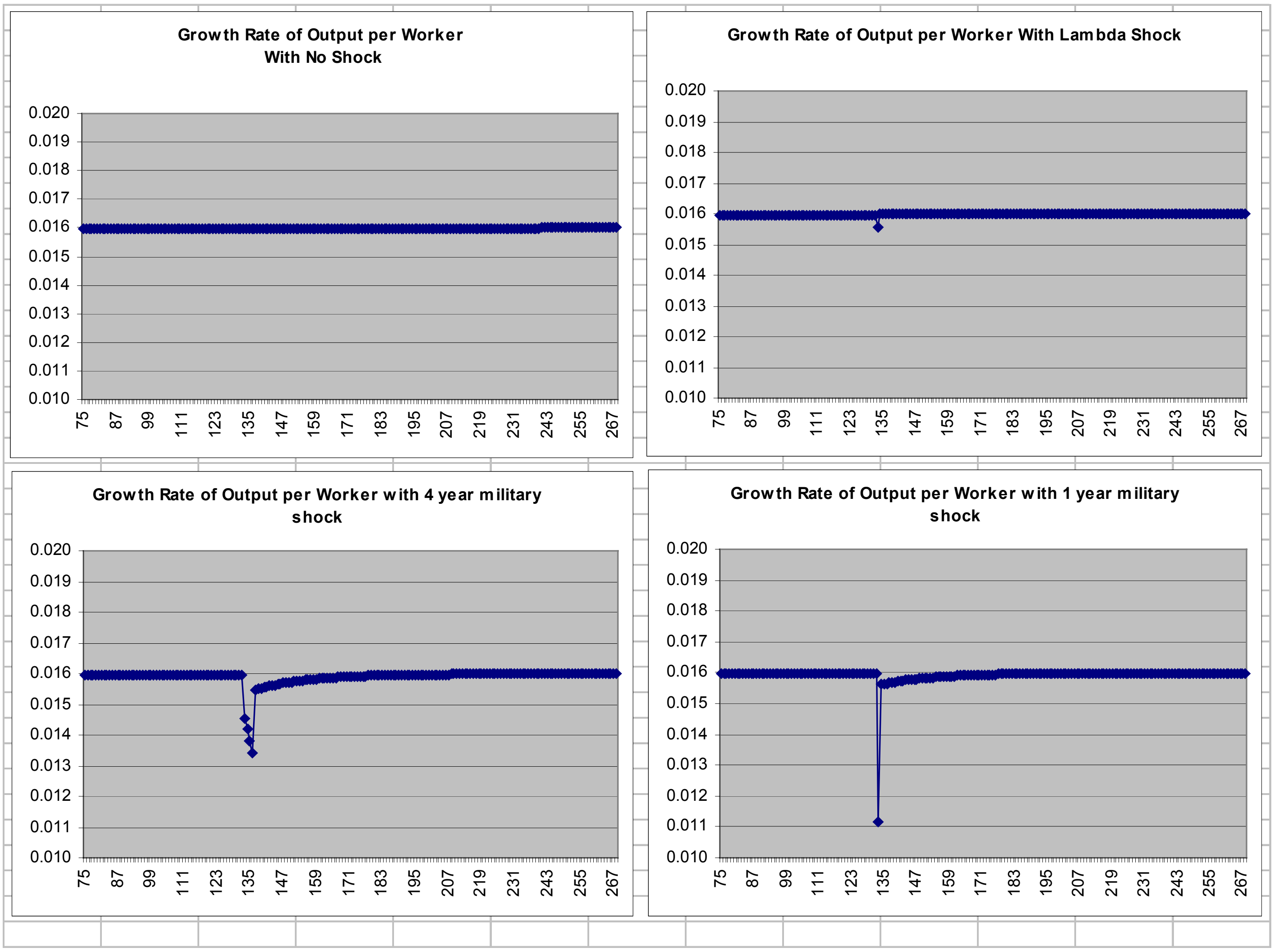
a. **b.**



c. **d.**

Figure 2

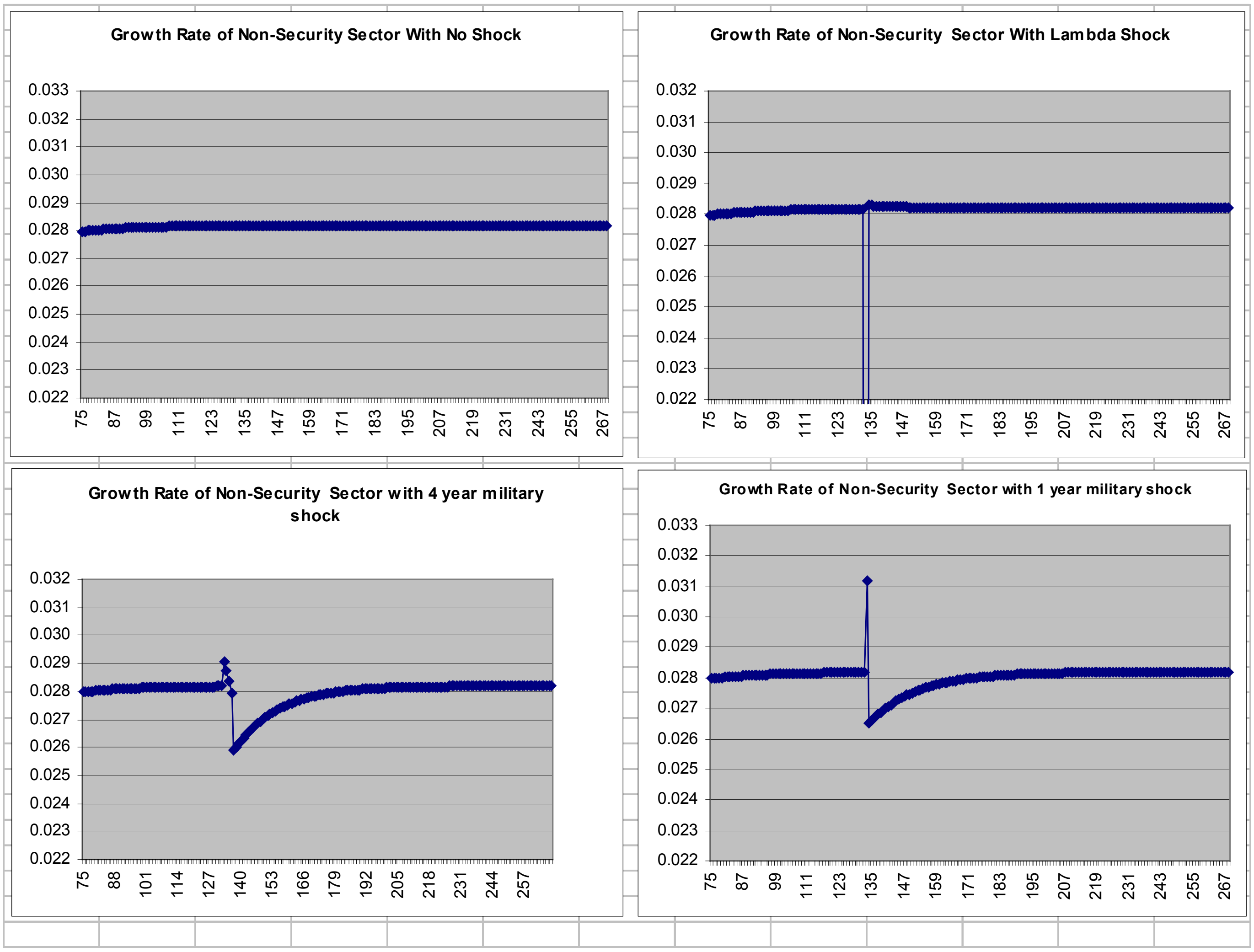
a. b.



c. d.

Figure 3

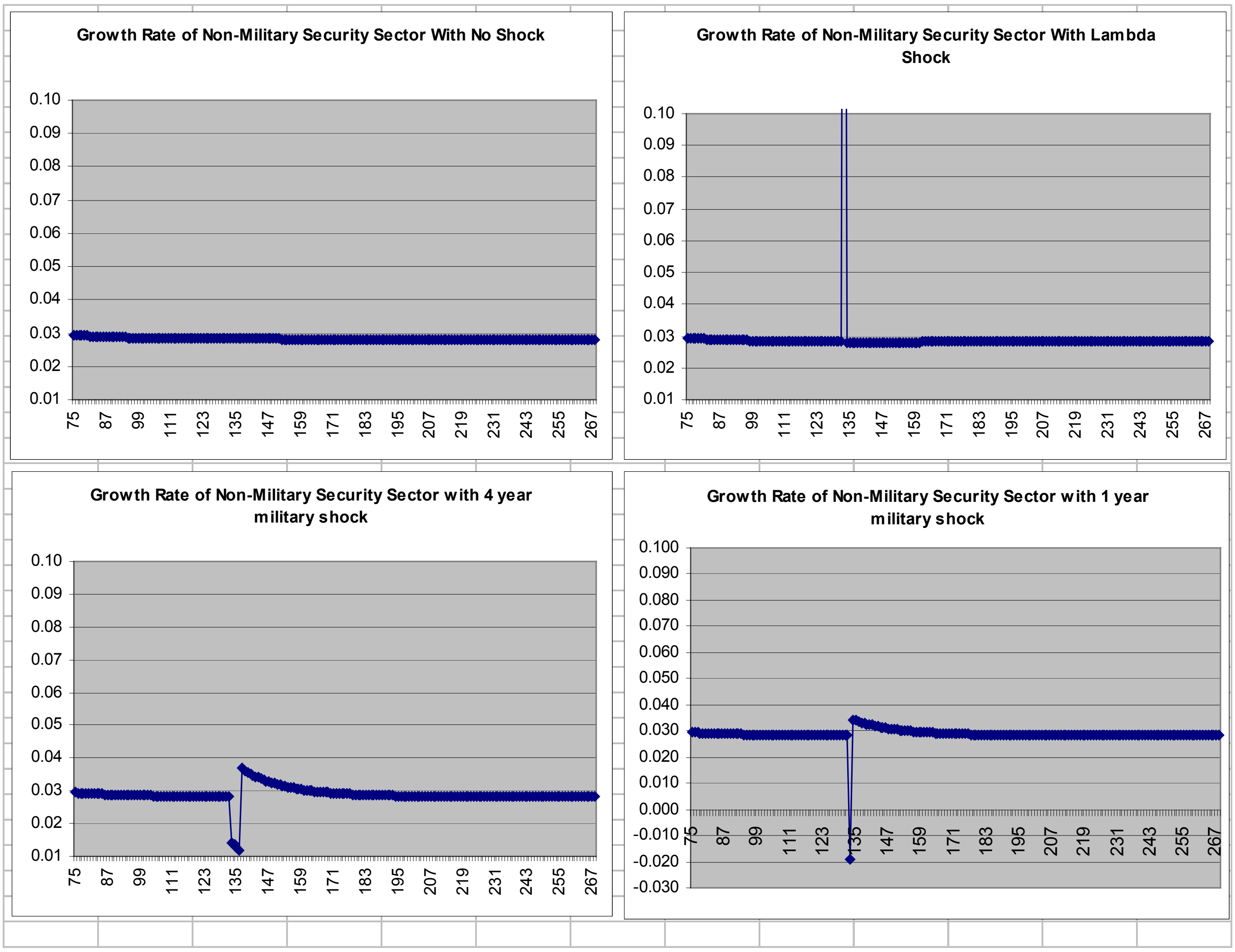
a. **b.**



c. **d.**

Figure 4

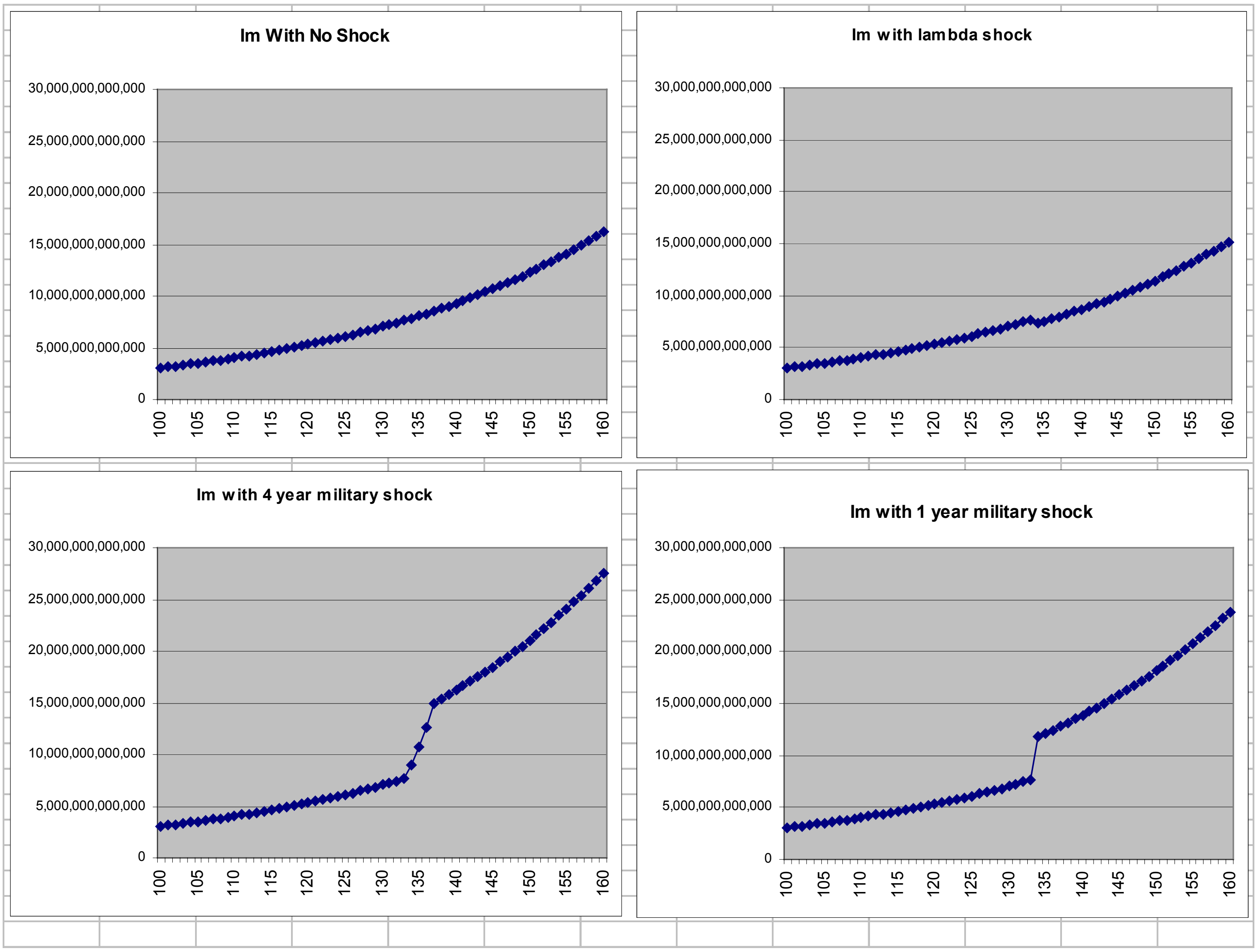
a. **b.**



c. **d.**

Figure 5

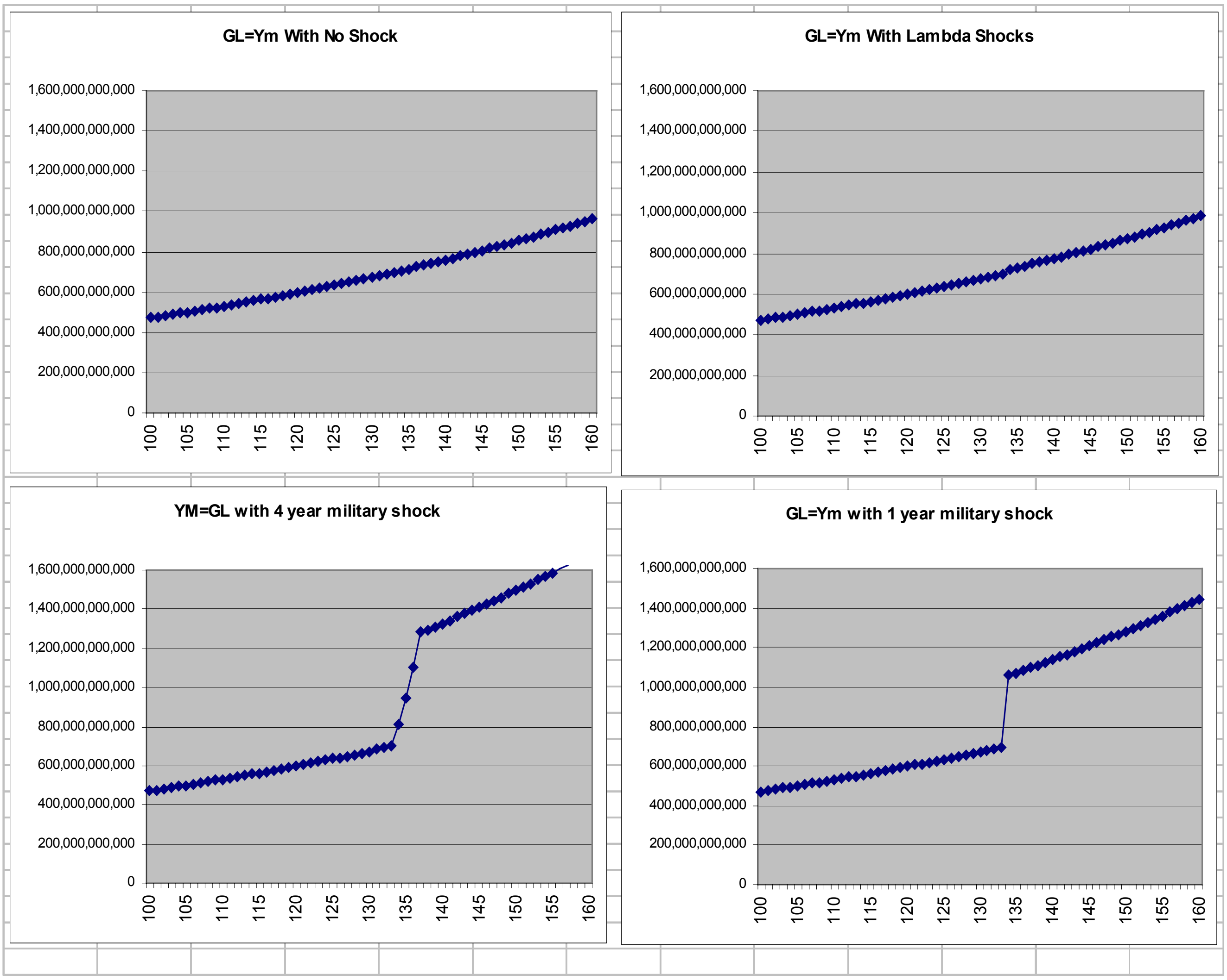
a. **b.**



c. **d.**

Figure 6

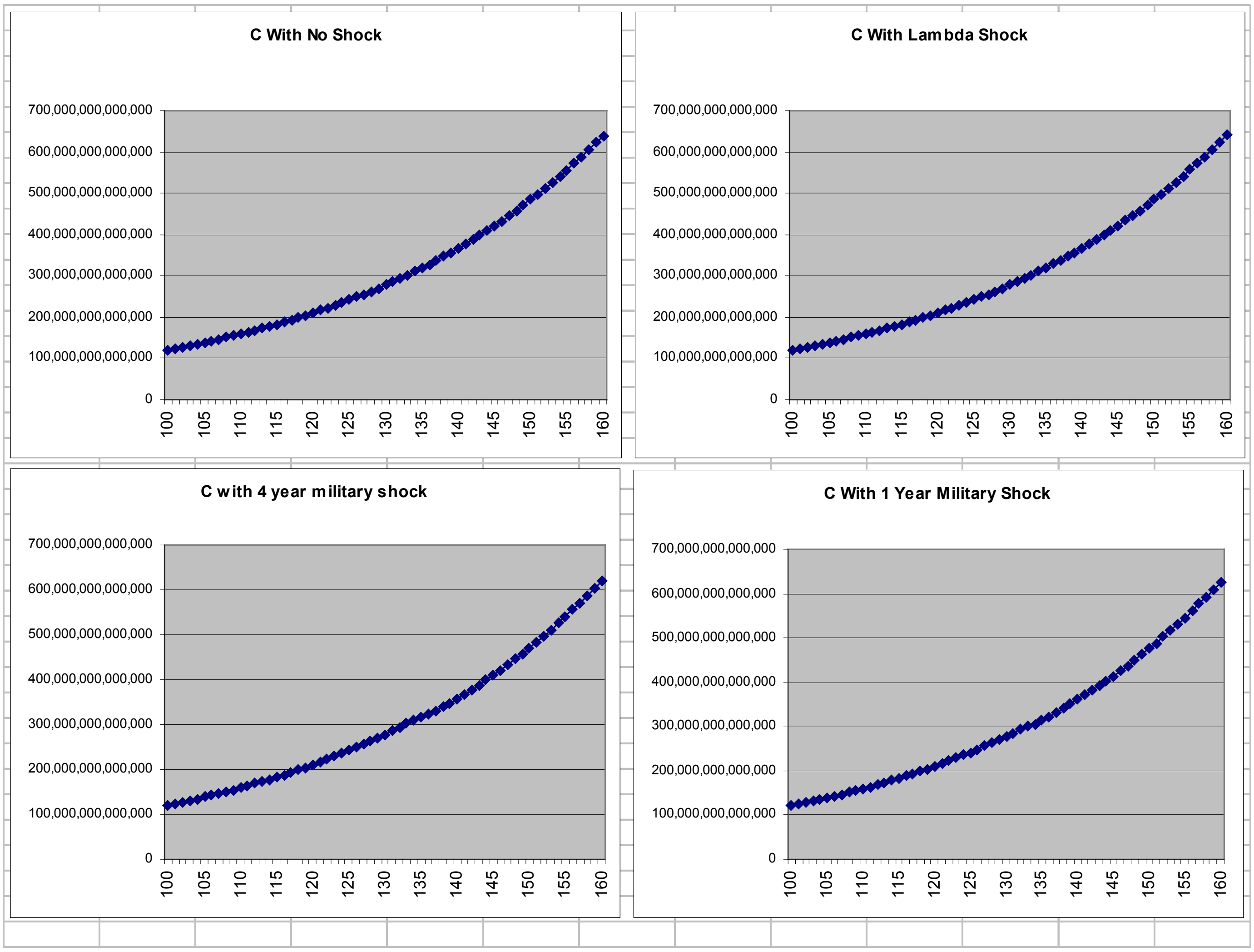
a. b.



c. d.

Figure 7

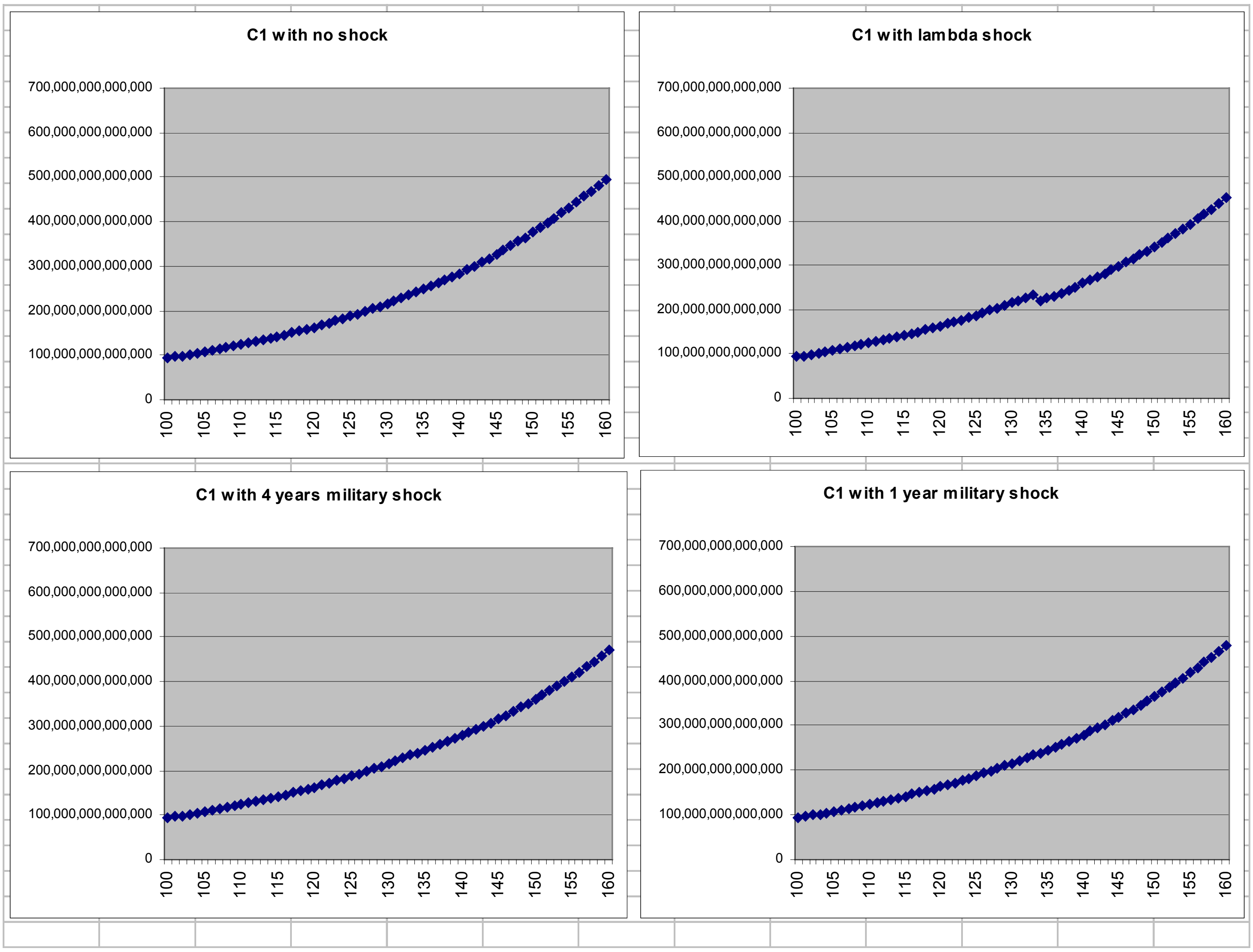
a. **b.**



c. **d.**

Figure 8

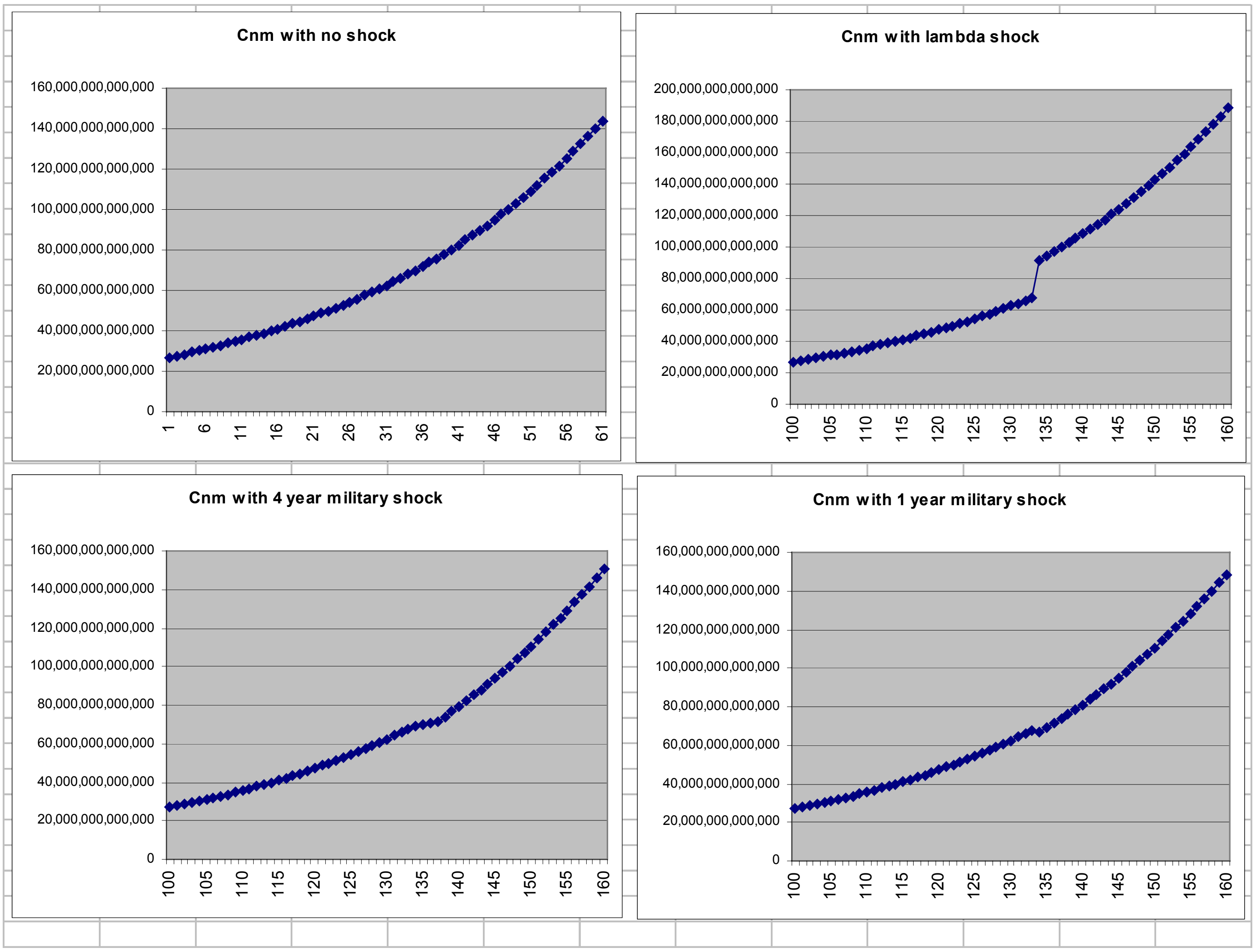
a. b.



c. d.

Figure 9

a. **b.**



c. **d.**