Production Possibilities and the Guns versus Butter Trade-Off

Modern economies are highly complex. In the United States economy in 2006, for example, 145.8 million workers combined their labor with $23.1 trillion worth of capital to produce $13.2 trillion worth of goods and services. Fortunately, the concepts and principles that guide economists’ understanding of economic activity are relatively simple. In this chapter we explain selected aspects of the economics of production such as the production function, scarcity, production possibilities, opportunity cost, efficiency, comparative advantage, and gains from trade. We then apply these principles to better understand the economic costs of conflict, the effects of defense spending on economic growth, and the depressed state of North Korea’s militarized economy.

2.1. Production Possibilities Model

Production Function

Assume that an economy produces two types of goods: military \( (M) \) and civilian \( (C) \). Military goods include tanks, fighter aircraft, and the like, while civilian goods encompass food, clothing, shelter, and so on. In economics, military goods are often called “guns,” while civilian goods are called “butter.” The production of military and civilian goods requires inputs such as labor \( (L) \) and capital \( (K) \), where the latter refers to physical assets like buildings and machines. A production function specifies the maximum amount of a good that can be produced with any given combination of inputs under the current state of technology. Technology is the scientific and organizational knowledge available to transform inputs
into outputs. Production functions for $M$ and $C$ can be summarized algebraically as:

$$M = f(L_M, K_M) \quad (2.1)$$

$$C = g(L_C, K_C), \quad (2.2)$$

where $L_M$ and $K_M$ are labor and capital inputs in military production and $L_C$ and $K_C$ are the same for civilian production.

Equations (2.1) and (2.2) represent production functions in general functional form, but economists often work with specific functional forms. The most famous specific production function in economics is the Cobb-Douglas function, which for $M$ and $C$ can be written:

$$M = AL_M^a K_M^b \quad (2.3)$$

$$C = \tilde{A}L_C^a K_C^b. \quad (2.4)$$

In equations (2.3) and (2.4), the $A$ and $\tilde{A}$ terms are positive constants representing the state of technology in the production of military and civilian goods. The positive parameters $a$, $\beta$, $\alpha$, and $b$ capture the productive capability of the inputs. The parameters for production functions often can be estimated statistically using historical data, but for our purposes a numerical example is sufficient to understand the functions. Suppose $A = 50$, $a = 0.5$, and $\beta = 0.5$ in equation (2.3). If labor and capital inputs are $L_M = 100$ hours and $K_M = 9$ units, then military output would be $M = 50(100)^{0.5}(9)^{0.5} = 1,500$ units.

Two well-known production concepts are marginal product and returns to scale. Marginal product is the change in output that occurs when one unit of a given input is added, holding other inputs constant. In mathematical terms, it is the partial derivative of output with respect to the given input. For example, using the Cobb-Douglas production function for military goods, the marginal product of labor is $\frac{\partial M}{\partial L_M} = aAL_M^{a-1}K_M^\beta$. Given parameter values $A = 50$, $a = 0.5$, and $\beta = 0.5$ and the input values $L_M = 100$ and $K_M = 9$, the marginal product of labor in the military industry is $MP_{L_M} = 7.5$. This means that if labor input is increased by one hour (holding capital fixed), military output will rise by 7.5 units. According to the law of diminishing returns, as the amount of an input increases (holding the other input fixed), after some point its marginal productivity will diminish. For example, if $L_M$ is raised to 144 and $K_M$ held fixed at 9, the marginal product of labor in the military industry diminishes from 7.5 to 6.25 units. Note that this means that even though the total
output is now larger, the addition to the output is now smaller. Now consider increasing both inputs at the same time. For example, suppose both inputs are doubled, so that output becomes \( M = 50(200)^{0.5}(18)^{0.5} = 3,000 \) units. Doubling both inputs causes output to exactly double, which is known as constant returns to scale. For the Cobb-Douglas production function, constant returns to scale exists when \( a + \beta = 1 \). If \( a + \beta > 1 \), doubling inputs causes output to more than double, which is known as increasing returns to scale. If \( a + \beta < 1 \), doubling inputs causes output to less than double, which is called decreasing returns to scale.

### Production Possibilities Frontier

In economics, the fundamental fact of nature is scarcity, whereby individuals, groups, and nations have limited resources and technology to produce goods and services to meet peoples’ virtually unlimited wants. Assume that the labor and capital employed in the military and civilian sectors equal the total labor and capital available to the economy, \( L \) and \( K \):

\[
L = L_M + L_C \tag{2.5}
\]
\[
K = K_M + K_C \tag{2.6}
\]

The scarcity of labor and capital is reflected in equations (2.5) and (2.6), while the technological limits to production of goods for given input combinations are implied by the production functions (2.3) and (2.4). Technological limitations in production and scarcity of inputs imply a production possibilities frontier (PPF) such as that shown in Figure 2.1. Points on or within the PPF constitute the attainable region, which includes all combinations of guns \( (M) \) and butter \( (C) \) that are possible to produce within an economy.

The PPF in Figure 2.1 depicts the fundamental notion of scarcity in two ways. First, all combinations of guns and butter above the PPF lie in the unattainable region, meaning they cannot be produced given the available resources and technology. Second, the slope of the PPF is negative, meaning there exists a production trade-off between the two goods. At any point on the PPF, say point \( A \), the only way to obtain more guns (moving to point \( B \), say) is to give up some butter. When production is on the frontier, gaining more of one good requires giving up or forgoing some of the other good. This trade-off is captured by the concept of opportunity cost. In Figure 2.1, the opportunity cost of an increase in guns from \( m^1 \) to \( m^2 \) is the \( c^1 - c^2 \) units of butter given up. Note that the PPF in Figure 2.1 is bowed out. This indicates that the opportunity cost of a good will increase
as more of the good is acquired. For example, in moving from point $B$ to point $E$, even more units of butter must be given up for an equal increment of guns than when moving from point $A$ to point $B$. Economists believe that PPFs are usually bowed out because resources shifted from the production of one good to another tend not to be equally adaptable.

As depicted by the PPF, many alternative production points exist; hence, choice is inescapable. Among the thousands of goods and services that might be produced in a modern economy, decisions must somehow be made about what quantities of which goods will be produced, what combinations of inputs will be used, where the goods will be produced, how the goods will be distributed, and how all of these things will be coordinated and adjusted as technology, resources, and peoples’ preferences change over time. Different nations have different economic systems for addressing these issues. In the United States and many European nations, there is substantial private ownership of property and a reliance on markets (supply and demand) to coordinate economic activity. In North Korea and Cuba, most property is not privately owned, and economic activity is directed by state central planning. Other economies have somewhat limited private property yet a significant role for markets (e.g., China).
Figure 2.1 can also be used to understand the concepts of productive and allocative efficiency. Productive efficiency occurs when inputs are fully employed, so that equations (2.5) and (2.6) hold, and maximum output is produced from those inputs based on available technology, so that equations (2.3) and (2.4) hold. When productive efficiency is achieved, the economy operates at some point on the PPF. If the economy fails to employ all resources fully and productively, then it operates at a point inside the PPF, which is called productive inefficiency. Allocative efficiency, also known as Pareto efficiency, occurs when it is not possible to improve one individual’s or group’s well-being without hurting another’s. For example, suppose the economy is operating at point B in Figure 2.1, which is productively efficient. Now assume that the movement from point B to point A makes everyone better off, but that any further move from point A will leave at least one person worse off. This would imply that B is productively efficient but not allocatively efficient, whereas A is both productively and allocatively efficient.

Specialization and Trade in the Production Possibilities Model

The authors of this book produce teaching and research services, and maybe a few vegetables from gardening, but they consume hundreds of other products. Our case is typical of workers in modern economies who specialize in the production of one or a few items and then trade their specialized output (with money facilitating exchange) for the goods they consume. Specialized production and trade is a fundamental aspect of economic life, not only for individuals but also for nations.

In Figure 2.2 we depict specialized production and trade using the production possibilities model. Recall that along a PPF there exists a trade-off between one good and another. This trade-off is internal to the country; that is, within the country’s own production possibilities, it can trade off one good for another as reflected in the slope of its PPF. But there is another possibility available to the country; namely, it can trade some of its output with another country. This is an external exchange possibility. In Figure 2.2 we draw a curved line, known as an indifference curve, tangent to the PPF. We will discuss indifference curves in more detail in Chapter 3, but for now it is sufficient to say that points along any given indifference curve generate a fixed level of well-being or utility, and that the higher the indifference curve, the greater the well-being or utility. In Figure 2.2, if the nation produces goods only for itself and does not trade, the highest attainable indifference curve is the one that is tangent to the PPF (labeled $aa$), say at point A. Point A
is known as an autarky optimum, because it is where the country would produce to maximize its material well-being in the absence of any external trade. Assume the opportunity cost of military goods in the neighborhood of point $A$ equals $-1$, meaning that the production of an additional unit of $M$ would cost one unit of $C$ forgone. But suppose that prices on world markets are such that one unit of $M$ could exchange for two units of $C$. This external terms-of-trade is represented by the line with slope $-2$ drawn tangent to the PPF at point $B$. With external trade, the country can achieve a higher indifference curve and therefore a higher level of well-being by following an “economic two-step.” First, it specializes more in the production of $M$ by moving its production point from $A$ to $B$. Second, it trades away some $M$ in return for some $C$, arriving at a final consumption point $E$ on the higher indifference curve $ee$. The distance $FE$ represents the country’s exports of $M$, while $BF$ represents its imports of $C$.

Figure 2.2 shows that specialized production and trade allow the country to consume more goods and services than it could produce in isolation. At consumption point $E$, the country is consuming a bundle of goods that lies outside the PPF. Although $E$ is an unattainable production point, it is not an unattainable consumption point because of the opportunity presented by external trade. When specializing in a product (good $M$ in this case) that is
more valued on world markets relative to the opportunity cost of producing it in isolation, the country is operating according to what is known as its comparative advantage. Such specialization increases the value of the country’s production and, through trade, allows the country to reach a higher indifference curve. The increase in the indifference curve from \( aa \) to \( ee \) is a graphical representation of the gains from trade.

**Economic Growth in the Production Possibilities Model**

Over time, most economies experience an increase in the amount of goods and services that are produced as more labor and capital and better technology become available. This is known as economic growth. For example, since the early 1940s, a growing proportion and number of women have entered the work force in the United States, contributing to its post–World War II growth in gross domestic product (GDP). In some countries, such as Afghanistan prior to the fall of the Taliban in 2002, women have been discouraged or forbidden from paid employment, which tends to depress GDP growth. When new resources or technology become available, the PPF moves outward, causing some previously unattainable production points to become attainable. The PPF does not necessarily shift out equally along the two axes. If resources or technological developments are biased in favor of, say good \( C \), the PPF would shift out more along the \( C \) axis than the \( M \) axis. Note also that the PPF can shift in, which constitutes negative economic growth. For example, Hurricane Katrina destroyed lives and capital stock in New Orleans and Southern Mississippi in 2005, causing the PPFs for these local economies to shift inward.

**2.2. Applications**

**Economic Costs of Conflict**

In Chapter 1 we indicated that violent conflict involves economic costs of three sorts: diversion of resources to defense, destruction of goods and resources, and disruption of present and future economic activities. Figure 2.3 illustrates these three types of costs in the production possibilities model. Conflict typically leads to an increase in military production as a proportion of overall production. In panel (a), the increase in military goods relative to civilian goods causes the production point in the economy to move from say \( A \) to \( B \). In this case, the increase in “guns” from \( m^1 \) to \( m^2 \) occurs at the expense of “butter,” which declines from \( c^1 \) to \( c^2 \). In
panel (b), the destruction of goods, capital, and people through violent conflict causes production possibilities to shrink, reflected by the inward shift of the PPF. In this example, violent conflict leads to negative economic growth. In panel (c), disruption of trade by conflict leads to a decline in material well-being. Initially, the country produces at point $B$, exports $FE$ units of $M$, imports $BF$ units of $C$, and reaches indifference curve $ee$ at consumption point $E$. Assume now that trade ceases with conflict. This causes the country to operate in autarky at point $A$, with reduced consumption of each good and a lower level of utility shown by indifference curve $aa$.

Figure 2.3. Economic diversion, destruction, and disruption from violent conflict.
Defense Spending and Economic Growth

There are multiple channels by which defense spending can impact a nation’s economic growth. Figure 2.4 considers three of the major channels: (a) crowding out, (b) crowding in, and (c) growth spin-offs. In panel (a), assume that the preponderance of a nation’s investment goods (i.e., new machines and factories) is embodied in civilian goods \( C \). If the nation operates at point \( A \), it will have a relatively large amount of investment goods this year leading to a relatively large capital stock next year and a correspondingly higher PPF. If the nation operates at point \( B \), however, it will have
a relatively small amount of investment goods this year, leading to a relatively small capital stock next year and a correspondingly lower PPF. Thus, when the nation chooses more military goods (point B rather than point A), it crowds out or dampens capital accumulation, leading to diminished economic growth. In panel (b), assume that the nation is initially operating at inefficient point I, perhaps because the country is experiencing a recession with underutilized labor and capital. In this case, increased defense spending can stimulate economic activity, moving production from I to I', for example. The increase in production of military goods raises the incomes of workers and owners in the military sector. These income earners will spend some of their increased income on civilian goods, causing civilian goods production to rise from I' to E via a multiplier effect. This stimulation of civilian production is called crowding in. Panel (c) looks like panel (a) except that the arrow from point B is now longer than the arrow from point A. Suppose that greater defense spending leads to what are called growth spin-offs, such as increases in education and advances in technology. If this is the case, the diversion of resources to military goods when moving from A to B can cause the future PPF to be further out than otherwise.

Following the end of the Cold War in 1989, the defense spending–economic growth relationship was of particular interest because it was thought that defense spending would fall throughout the world. Many scholars expected a “peace dividend” in the form of greater economic growth, based on the view that defense spending dampens economic growth as shown in panel (a). Other scholars warned that cuts in defense spending could have a recessionary impact or could dampen technological development as suggested by panels (b) and (c). Of course, the multiple channels by which defense spending can affect economic growth are not mutually exclusive. For example, consistent with panel (b), it is possible that cuts in real US defense spending from 1989 to 1991 could have contributed to the recession of 1990–91. On the other hand, consistent with panel (a), the resources freed up from cuts in US defense spending may have been partly responsible for the rapid economic growth experienced by the United States in the later 1990s. As briefly reviewed in this chapter’s bibliographic notes, empirical evidence on the relationship between defense spending and economic growth is mixed.

North Korea

The Korean demilitarized zone (DMZ), established after the Korean War (1950–53), serves as a buffer zone separating North and South Korea. Despite attempts at reconciliation, the DMZ is one of the world’s most
militarized areas, with close to two million troops (including approximately 27,000 US troops) and a large stock of pre-positioned military equipment ready for immediate deployment should hostilities break out. The tension on the Korean Peninsula is heightened by North Korea’s long-range missile capabilities and its continuing research into nuclear, biological, and chemical weapons. On October 9, 2006, North Korea claimed that it had successfully detonated a nuclear device. Ongoing efforts to resolve the status of North Korea’s nuclear weapons and energy programs have occurred in the context of the “six-party talks” (North Korea, China, Japan, Russia, South Korea, and the United States).

Table 2.1 summarizes selected economic and military data for North and South Korea and for the South’s ally, the United States. The data on armed

<table>
<thead>
<tr>
<th>Economic Variables</th>
<th>North Korea</th>
<th>South Korea</th>
<th>United States</th>
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<tbody>
<tr>
<td>Gross domestic product (GDP)</td>
<td>$40.0 billion</td>
<td>$1,206.0 billion</td>
<td>$13.9 trillion</td>
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<tr>
<td>GDP per capita</td>
<td>$1,900</td>
<td>$24,600</td>
<td>$46,000</td>
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<tr>
<td>Military spending as % of GDP</td>
<td>22.9%</td>
<td>2.7%</td>
<td>4.1%</td>
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<table>
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<tr>
<th>Armed Forces</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Active armed forces</td>
<td>1,106,000</td>
<td>687,700</td>
<td>27,114</td>
</tr>
<tr>
<td>Active paramilitary forces</td>
<td>189,000</td>
<td>4,500</td>
<td>0</td>
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<tr>
<th>Weapons</th>
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</thead>
<tbody>
<tr>
<td>Main battle tanks</td>
<td>3,500</td>
<td>2,330</td>
<td>116</td>
</tr>
<tr>
<td>Artillery</td>
<td>17,900</td>
<td>10,774</td>
<td>45</td>
</tr>
<tr>
<td>Surface-to-air missiles</td>
<td>10,000</td>
<td>1,090</td>
<td>1 battalion</td>
</tr>
<tr>
<td>Tactical submarines</td>
<td>63</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Principal surface combatants</td>
<td>8</td>
<td>44</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: North Korea’s military spending as a percentage of GDP is for 2003. GDP and GDP per capita data are at purchasing power parity. US armed forces and weapons data are for the Korean Peninsula only.

forces and conventional weapons for the United States represent US deployment on the Korean Peninsula. Three summary observations follow. First, North Korea’s national output or gross domestic product (GDP) in 2007 was less than 4 percent of South Korea’s GDP. On a per person basis, North Korea produced only $1,900 worth of goods and services in 2007, whereas South Korea created $24,600. These figures are striking because North Korea’s per capita GDP and economic growth rate were greater than the South’s in the years immediately after the Korean War (Kim 2003, p. 77). The stagnation of North Korea’s production is all the more shocking given that approximately 2.5 million of its people starved to death between 1995 and 1997 (Natsios 2001, pp. 212–215). Second, North Korea’s defense burden is extraordinarily high. In 2003, North Korea devoted 22.9 percent of its GDP to military spending. To put that figure in perspective, data elsewhere for 2003 show that only three other countries, Afghanistan, Eritrea, and Oman, had defense burdens exceeding 10 percent (Stockholm International Peace Research Institute 2007, pp. 317–323). Despite widespread famine in the 1990s and on-going problems with food provision, North Korea continues to deploy over one million troops and a substantial number of weapons. Third, the 189,000 paramilitary forces actively deployed in North Korea is a huge number compared to the number deployed by the South. Although North Korea fears its external enemies, its leaders also fear internal unrest, as evidenced by the large number of paramilitary forces.

We can use the production possibilities model to explore three elements that have contributed to North Korea’s severe economic and humanitarian problems: high defense burden, sclerotic central planning, and paucity of external trade. As shown in Figure 2.4(a), a high defense burden leads to resource diversion along a production possibilities frontier. If crowding out of capital accumulation outweighs crowding in and growth spin-offs from defense, then a high defense burden will stifle growth and possibly even shift the production possibilities frontier inward (negative growth). A second source of economic decay in North Korea is communist central planning. When a few leaders attempt to answer for a large population the vastly complex questions of what will be produced, who will produce it, and who will receive it, economic stagnation eventually emerges. Central planning tends to stifle movements of labor and capital into new industries and locations, causing an economy to operate at an inefficient point inside the PPF, such as point I in Figure 2.4(b). Moreover, when the distribution of the fruits of new investments is determined by central planners, initiative and innovation can be stunted, causing the PPF to grow more slowly than it would otherwise. Third, as a somewhat insular economy, North Korea has pursued
comparatively little external trade. For example, exports in 2003 as a percentage of GDP were estimated to be 5.3 percent for North Korea as compared to 23.5 percent for South Korea. As we saw in Figure 2.2, external trade allows a state to consume goods and services beyond what it is able to produce in isolation. To the extent that North Korea pursues little trade, it ends up on an unnecessarily low indifference curve much like $aa$ in Figure 2.3(c).

2.3. Bibliographic Notes

Production function concepts in general and the Cobb-Douglas production function in particular are covered in intermediate microeconomics texts (e.g., Nicholson and Snyder 2008). Graphical presentations of the production possibilities model are available in economics principles texts (e.g., Mankiw 2007), with more advanced treatments in many intermediate microeconomics books (e.g., Pindyck and Rubenfeld 2009). Principles texts generally cover comparative advantage and the gains from trade, but few do so using the production possibilities model. For coverage of these topics in a production possibilities framework, see intermediate microeconomics texts (e.g., Pindyck and Rubenfeld 2009, Waldman 2009) or international trade texts (e.g., Krugman and Obstfeld 2009). Virtually all principles and intermediate texts in macroeconomics cover economic growth (see, e.g., Hall and Papell 2005, Taylor and Weerapana 2009).

Benoit’s (1973) path-breaking study of the effects of defense spending on economic growth stimulated a vast literature. Based on a sample of 44 developing countries over the 1950–65 period, Benoit (1973, p. xix) concluded that the more that countries “spent on defense, in relation to the size of their economies, the faster they grew – and vice versa.” Since Benoit, studies have employed more sophisticated models and methods, included developed economies in the samples, and considered more channels by which defense spending might affect growth (see, e.g., Deger and Sen 1995, Ram 1995, Aslam 2007). In a review of the literature, Dunne, Smith, and Willenbockel (2005) conclude that defense spending is a significant determinant of economic growth (positive in some studies, negative in others) in the conflict economics literature but not in the mainstream growth literature. They attribute the mixed message from the two literatures to the use of different theoretical models.