

# EDUCATION PRODUCTION FUNCTIONS (Part 1)

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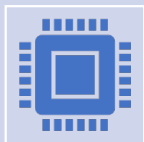
# INTRODUCTION



**Economic of education** – the study of the production of education, of how schools use a set of inputs, say teachers, textbooks, and computers, for example, to produce an educational good such as test scores, school attainment, or student engagement.



The fundamental analytic tool economists use in this line of work is **the education production function**.



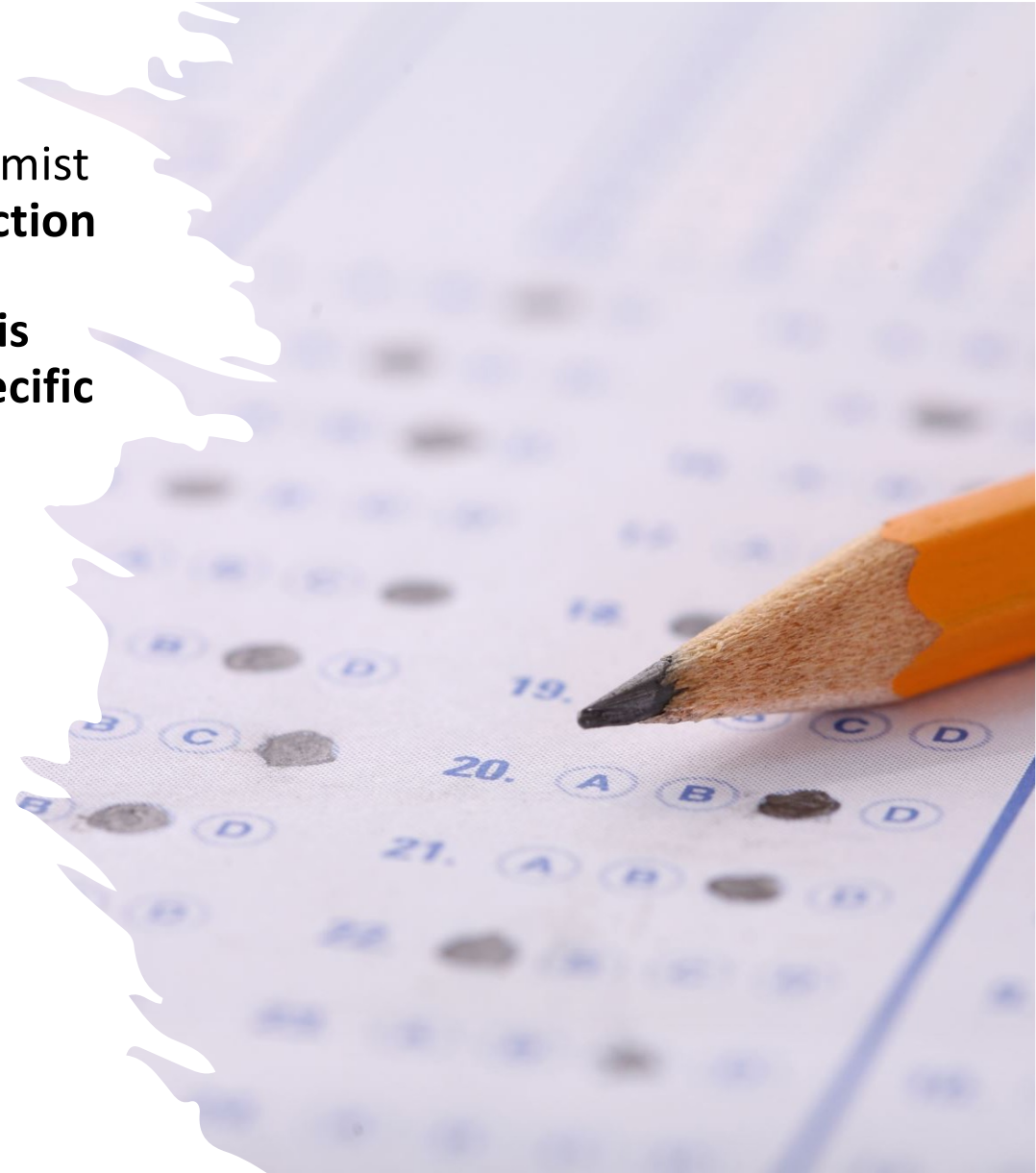
These functions are intended to show **how much of the educational good, or output, can be produced from specific amounts of a certain set of inputs**.

For example, **an economist would use an educational production function to predict how students will perform on a science test**

In analyzing science test performance, the economist would be interested in research questions of the following type:

- Do students who receive at least 50 minutes of science instruction five days a week receive higher scores than students receiving less than 50 minutes of science instruction a day?
- Do students whose science instruction includes a textbook published in the last two years outperform their peers who have access to older science textbooks?
- Do students taught by teachers with advanced scientific training score higher on the exam than those students taught by teachers lacking such training?

- To answer each of these questions, the economist would estimate **an education production function to determine how a specific input (daily instruction time, textbook, teacher training) is combined with other inputs to produce a specific output (science test scores).**



- The economist's findings regarding each of these questions can inform the education policy-making process as to which policies should be implemented by governments and school administrators .
- If the results reveal that test scores are higher when teachers have the advanced training, one could argue for the implementation of an education policy requiring all science teachers to have a master's degree in science.
- Policymakers supporting such a policy would believe that once all science teachers have completed this advanced training student tests scores will increase. They would base this belief on the results of the education production function.



The validity of any research finding from an education production function assumes that the economist has accurately captured in his education production function all the inputs used in the production process of science test scores.



If you were asked by the economist conducting this study **to list the educational inputs that influence a student's score on the science test, what would you put on your list?**

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Amount of science instruction received each day



Publication date of the textbook



Level of the teachers' scientific training



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- In order to study the complicated **education production process**, economists make many simplifying assumptions.
- These assumptions are taken from classical production theory that guides the economic study of the production process in a firm. As a group, these assumptions provide a framework for examining and explaining behavior.
- It is usually assumed that a firm's goal is **to maximize its profit**.
- **This profit maximization assumption** implies that **the firm will consume a set of inputs that minimizes costs while still producing a product that the firm can sell in the market and turn a profit**.
- Without this assumption, what would guide the firm's input use decisions? Are their decisions just pure happenstance? Is it possible to model happenstance?

When the assumptions of classical production theory are applied to the educational system, economists need to examine their applicability to the production of education

- What is a school's production goal?
- Returning to our economist examining the production of science test scores, is it appropriate to assume that schools seek to consume a set of inputs (e.g. instruction time, textbooks, and trained teacher) in order to maximize student test scores?


These are the types of questions that must be explored prior to using an education production function (EPF)

Based on the answers to these questions, simplifying assumptions must be altered where needed to enable an economic study to accurately capture the education production process and for its findings to correctly inform the policy making process





# Four main sections

1. The role of simplifying assumptions in economic analysis
  2. Assumptions of the production process
  3. Specifics on how to design and interpret the findings of an education production functions
  4. Presents two analytic tools (Cost effectiveness and Cost benefit analyses) related to EPF
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# I. The role of simplifying assumptions in economic analysis



# I. The role of simplifying assumptions in economic analysis


- One of the most common criticisms directed at economics from non-economists and those approaching it for the first time focuses on **the simplifying assumptions that all economic theories and statistical models rely on to make predictions about human behavior.**
- **An economist would respond by asking the critic to realize that we rely on simplifying assumptions whenever we make predictions about any social phenomenon.**

# Example



- An instructional technique, a mathematics teacher tells her students that once a week she will give them a pop quiz. The teacher believes that the prospect of a pop quiz will motivate her students to study and stay on top of the material in order to be prepared for the quiz, whenever it should be administered. She feels that without pop quizzes her students will wait until just before the final exam to study the material.
- A model of this phenomenon would predict that **students facing random pop quizzes will perform better on a final exam than students in a class without pop quizzes.**
- **The simplifying assumption is that students want to get a high grade in the class.**
- If the students want to get a high grade, they will realize that they must do well on the quizzes which in turn prepare them for the final exam.
- A related assumption is that students who continually study and review the material throughout the course will receive higher final exam scores than students who only study and review the material in the few days immediately prior to the final exam.
- Without these assumptions, the likelihood of failing a pop quiz will provide no motivation to students to study and thus students will be poorly prepared for the final exam.

- In the example of the mathematics teacher giving pop quizzes, **there are likely some students in the class who are not motivated to get a high grade in the course. Our simplifying assumption does not hold for them.**
- If we relax this assumption so that students no longer necessarily want a high grade, what are our explanations and predictions of human actions? How do they compare to our explanations and predictions when the assumptions hold?
- Economics models allow for this line of research and in doing so, provide further insight into whatever phenomenon is being studied.

- Assumptions establish this framework for the economist. (In fact, research in most disciplines such as sociology, political science, psychology, and anthropology rely on assumptions.) Without them, the economist would not know where to begin.



## II. Assumptions of the production process





## II. Assumptions of the production process

- The key assumptions of classical production theory that establish the framework for economic analyses of production are reviewed and their applicability to the production of education is discussed. When economists study production, they consider an industry and examine the behavior of the individual firms in that industry. **When production theory is applied to education, individual schools are viewed as firms and the school system as the industry.**
  - We begin with the assumption that a firm has a clearly defined ***production goal*** toward which the firm's behavior is directed. Leading the firm towards this goal is assumed to be an ***individual (or group of individuals) with decision-making authority***. This decision-making authority allows for ***control over the entire production process*** including the ***selection of inputs***. A firm's internal behavior is assumed to be restricted by the fact it ***faces competition from other firms*** in both the market for the inputs to its production process and the consumer market for its output or product.
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## II. Assumptions of the production process


- **Goal of production**
  - **Organization structure**
    - Leadership and decision making
    - Control over the production process
    - Selection of inputs and outputs
  - **Competitive market**
    - Input market competition
    - Output market competition
    - Barriers to entry and exit
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# Goal of production

Let's apply the assumption that a firm has one clear and well-defined goal for a school and its production of education

- What is a school's goal for the production of education?
  - Who identifies that goal?
  - Do school have a production plan that details how they will achieve the goal?
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- A school's goal of education production is **cost minimization**
  - Schools must provide an education to a given number of students – **a school's goal of production is to provide a quality education to all its students at minimum cost**
  - What characteristics does a quality education have? - that prevents schools from identifying one clear and well-defined goal to guide their production process
  - Education quality means different things to different people
  - People define education quality as **providing children with the necessary skills to be successful in life**
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- They disagree on what comprises those “necessary skills” and on what deems a life “successful”.
- Some argue that the necessary skills can be confined to the basics—language, writing, and mathematics.
- Others hold a more extensive view of “necessary skills” to include other academic subjects as well as curriculum in such areas as character and moral development, nutrition and physical health, and civic mindedness (e.g., political involvement and volunteerism).
- If a school used the former definition of necessary skills, they would cut their science, history, and arts curriculum to reduce production costs.
- However, if the later and broader definition were used, schools would seek increased public funding to expand their curricular offerings in order to meet this standard for educational quality.
- If a “successful” life is one where the individual is happy, how can schools tailor their production process so that its students can achieve their own concept of happiness over the course of their lifetime?

- The identification of one clear and well-defined goal of production is further hampered by the presence of more than one decision-maker.
- Yet, for a school, there are many disparate decision makers involved in setting the school's production goal and drafting its production plan.

- **Education policy** is determined by actors on multiple levels from governing bodies (state, local, and national) to school officials (principals and teachers) to parents to business and community leaders.
- Each level may define educational quality differently and thus have a different production goal .
  - **The national government** could establish the goal of maximizing student academic performance while the state government could insist that students graduate from secondary school.
  - **School officials** set the goal that students should attend school regularly.
  - **Parents** could set a goal that schools expose students to the fine and performance arts.
  - **Public safety officials** could insist that a quality education dissuade students from involvement in vandalism, and other crimes.

Embedded in each of these goals is at least one performance measure intended to provide assessment information on how successful the school has been with respect to achieving the goal.

- **The national government** could require that all student take end-of-year examinations in mathematics and language arts.
- **The state government** could require all secondary schools to annually report graduation and dropout rates.
- In order to meet the production goal established by **local parents**, schools would require that each student complete a specific number of courses in the fine and performing arts.
- **Public safety officials** would analyze incidence rates of youth perpetrated crime.

- With such multiple and potentially competing production goals and their associated performance measures, it is much more challenging for a school to devise one production plan that can achieve all goals.
- The absence of a clear definition of a quality education leaves to the school with a set of goals that may not necessarily be achievable with one production plan.

- Actions that the school must undertake to maximize test scores analyzed by the national government may conflict with actions needed to achieve the goal established by the parents (i.e., that students be exposed to the arts) and the goal imparted by the public safety officials (i.e., that youths be dissuaded from criminal activity). Assume each goal requires the following actions:



## Table 1: Actions and Associated Production Goals


Goal	Action
Maximize academic performance	One hour of instructional time in each of the tested subjects each day
Expose youth to the fine and performing arts	45 minutes each week in each discipline, fine arts and musical arts
Reduce youth-perpetrated criminal activity	One hour once a month of instructional time on the negative consequences of various criminal activities


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- You can see that these goals place demands on a significant portion of the time students spend in school.
- This leaves little time for other school activities, such as instruction in non- tested subjects, physical education, lunch and recess.
- The actions also require that schools fund these activities.
- Consequently, schools have less funding and less flexibility in allocating funds to the other aspects of their education production process.
- It could very well be that cuts in one area of the production process have a negative impact on another area.



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- Putting together one production plan that enables a school to achieve its multiple and potentially conflicting production goals is a very challenging mandate.
  - When using an education production function, the analyst must carefully examine **how the educational outcome being analyzed**—college attendance rates, for example—is aligned to the goals of the school.
  - If the outcome and the goals are well aligned, it is a safe assumption that the productive actions the school undertakes are associated with the outcome.
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- For example, if the school's goal is to maximize academic achievement, its actions directed at achieving that goal would also lead to more students enrolling in college. (It's easier to get into college with good grades and high test scores.)
  - However, if the school's goal is to maximize graduation rates, it could be that schools relax academic standards in order to increase the graduation rate.
  - This could leave students less prepared for college and cause fewer of them to enroll.
  - In this instance, the analyst would be in error to assume that the school's actions are intended to maximize college enrollment rates.
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# Organization structure

- These assumptions are that the firm has an **entrepreneurial leader with decision-making authority**, the firm has control over the production process, and the firm can select what outputs to produce and which inputs to use in the production of those outputs.
  - Although interconnected and interdependent, these three characteristics of the firm's organizational structure
    - Leadership and decision making
    - Control over the production process
    - Selection of inputs and outputs
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# Leadership and decision making

- Economic production theory assumes that leaders are driven by rewards and sanctions - Is this system of rewards and sanctions present within the education industry guiding the production of education?
  - The principal is the leader of a school. She is hired by a governing body, be that a district or a school board, to oversee the production of education at the school.
  - As school principal, she is responsible for the quality of the learning environment including the upkeep of the school facility, the supply of educational materials, and the staffing of teachers.
  - Her customers are the parents and community members who expect the school to provide their youth with a quality education.
  - The school principal must find a way to provide the level of quality demanded within the financial constraints established by the community.
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- Assume the production goal of the school is to maximize math and reading test scores.
- Assume test scores are therefore the measure of quality used to assess the principal's job performance.
- If test scores are at levels deemed satisfactory by the governing body, the principal is judged to have performed well.
- However, if test scores fail to meet expectations, the principal's job performance is criticized.
- Certainly, the principal's performance is driven by the rewards and sanctions.

- Economic production theory assumes that in order for a firm's leader to be held accountable for the firm's successes and failures, the leader must have **decision-making authority** and those within the firm must acknowledge that authority.
- Decision-making authority tends to be more diffused and decentralized within the education industry.
- Multiple groups and individuals have decision-making authority over specific aspects of the production of education, increasing the likelihood that a decision made by one individual will directly conflict with another made by someone else.
- These decision-makers include the national ministry of education and local government, local school boards, district officials, and the school principal.

- Assume that **the school principal decides that in order for students to meet the performance expectations of the community they need to spend more time being instructed in mathematics and reading.**
- One option would be to increase the number of school days -however, that decision is made by the national ministry of education
- Another option is to make more efficient use of the time students are in school by requiring students to spend an hour each day studying mathematics and reading - however, spending more time on these two subjects reduces the time available for other subjects
- The decentralized nature of decision-making can restrict a principal's ability to lead the school and the school's ability to meet its production goal.



# Control Over the Production Process

- Intimately related to the issue of who possesses the decision-making authority is the issue of how much of the production process the authority encompasses - Is it broad enough to span the entire production process or is it more narrowly targeted?
  - Economic production theory posits that leaders with broader and deeper decision-making authority are better positioned to successfully guide their firm to the achievement of their production goal.
  - The breadth of a leader's decision-making authority is directly related to the degree to which the production process is centralized.
  - The more dispersed the process, whether that be spatial or temporal dispersion, the weaker the ability of the leader to influence the quality of the output. For this reason, **economic production theory assumes that a leader has control over the production process.**
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- The dispersed nature of the education production process makes it much more difficult for a school principal to exert quality control.
- Unlike the restaurant where meals are only produced when the restaurant is open, the education production process is not confined to the seven hours students spend at school five days a week nine months of the year.
  - It is not the case that students somehow close their brains to learning after they leave the school building. Rather, the production of education continues.
  - The rest of the time parents and the broader community are supervising and directing the education production process.
  - **The school has very little to no control over this aspect of production.**
  - Yet, the production that occurs outside the school's purview directly impacts the quality of the production within the school and makes it difficult to attribute student learning to processes that occur at the school.

- The connection between a student's academic performance and their living situation outside of school is well established in the EPF literature.
- Family socioeconomic status indicators such as family income, parental education attainment, and number of books in the home, are frequently shown to be factors in explaining why some students perform better than others.
- The very fact that schools assign homework reveals their belief that the production of education is not limited to the school building.
- Schools expect students to continue learning when not at school.

- Quality control is thus very difficult to enforce in such an environment.
  - Production is not as clearly delineated as in the firm.
  - This makes locating the source of the quality breakdown more of a challenge.
- With respect to education, students not only move around their community (e.g., home, school, etc.), but they also can move among schools.

- Were a school principal to undertake the effort of determining which stage of the education production process caused a specific student's poor test performance, she would surely be in for a huge challenge.
- Where does the process begin?
- Does it start when children begin formal schooling? Or does it begin earlier, maybe when children are first born?
- Given the dispersed nature of the production process, it will be very difficult for the principal to determine how all the players in the process are related, something that she must do if she is to craft and implement a plan to correct the quality flaw.

- And because the school does not control the entire production process, devising and implementing a solution may not even be possible.
- For example, assume the principal determined that the student was not receiving sufficient attention at home.
- The principal believes that the student's test performance would improve if his parents read to him more.
- However, the principal can only recommend this course of action to the parents.
- The principal's decision-making authority does not apply to aspects of the education production process that occur within students' homes.
- Consequently, principals must focus their quality control efforts on the production that occurs within the confines of their school.
- This serves to restrict their ability to lead their school toward the achievement of its production goal.



# Selection of Inputs and Outputs

- Economic production theory places particular importance on the ability of leaders to select which inputs to use in the production of which outputs.
  - The assumption that leaders have decision-making authority over the production process stresses that they use this authority to properly select the inputs and outputs that enable their firm to achieve its production goal.
  - This requires that leaders identify and select the **optimal production plan**.
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Essentially, a production plan is a recipe that explains **how a firm can produce some set of outputs, be that one output or more.** It tells the firm the quantity of the outputs that can be produced using specific quantities of each input. The general form for a **production plan** is:

$$(EQ. 1) Plan_1 = (output_1, output_2, \dots, output_M, input_1, input_2, input_3, input_N)$$

- This plan includes M outputs and N inputs, where both M and N are some positive non-zero number. Specifically, this plan indicates how much of each of the N inputs are required to produce some quantity of each of the M outputs. Notice that this plan has a subscript 1. There are multiple product plans for any given set of outputs and any given set of inputs.



The most efficient plan is the one in which all the productive capabilities of each input are maximized and waste is minimized.

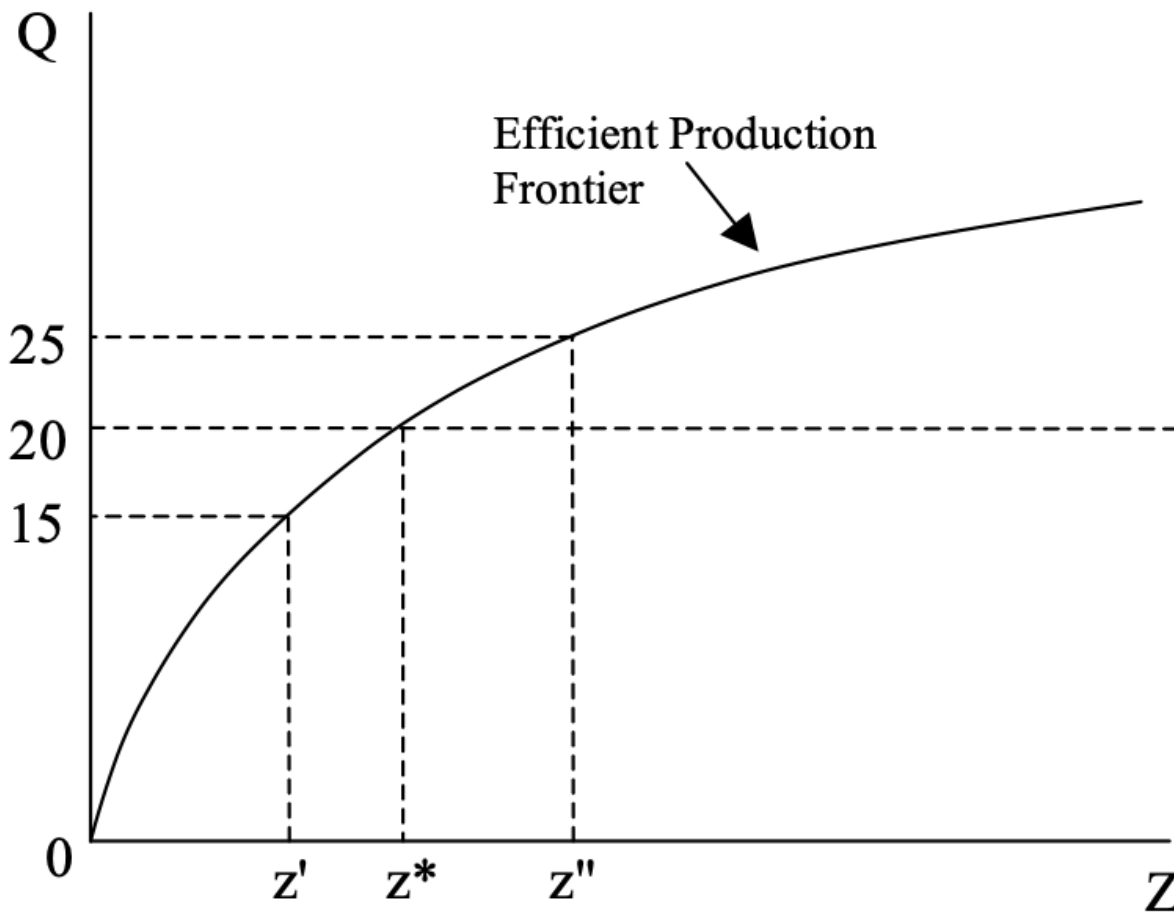


It is up to the leader to determine which production plan most efficiently meets the firm's production goal.



**The optimal production plan is the most efficient plan.**

# FIGURE 1: Efficient Production Frontier



The vertical axis indicates the quantity (Q) of the output to be produced.

The horizontal axis represents how much of the inputs (Z) are needed. (Assume that all the inputs included in these production plans have been combined into one number and that number is indexed on the horizontal axis.)

# EFFICIENT PRODUCTION FRONTIER

- The arched line is called **the efficient production frontier**.
- **The most efficient production plans** available to the firm.
- Each point below this frontier is a feasible production plan available to the firm.
- Points above the frontier are production plans not available to the firm.
- The frontier is the largest quantity of output the firm can possibly produce.
- In order to increase production, the firm must use more inputs, meaning they must move to the right along the horizontal axis.

- Schools do not have the same flexibility as firms in selecting which production plan to use.
- This is a direct consequence of the fact they do not control the entire production process.
- Recall, a leader can only apply her decision-making authority to alter the school's consumption of the inputs and the production of the output over which it exerts control.
- For all other inputs and outputs, schools must accept the production decisions made by others and make their decisions around those of others.

- Consider the school principal who feels her school can most efficiently meet its production goal by having students spend more time in school. This, she believes, will provide teachers with more time to cover material and for students to practice under the guidance of the teachers. The principal feels that students should have 20 more school days each year. However, this is an input outside the purview of her decision-making authority. A governing agency has already decided the length of the school year. As a result, the principal can not select any production plan that contains more or less school days than determined by the governing agency.

- **Many of the most important inputs to education are outside the purview of the principal's decision-making authority.**
- **Students, the most central input to education,** are a perfect example. Most publicly-funded schools can not select which students attend their school.
- Instead, they are required by law to admit all students within a geographically defined service area.
- **The other resources available to a school—such as teachers and instructional materials—** may be best suited to a certain kind of student.
- Thus, the school's education production process would be most efficient if it only served that certain kind of student.
- This is a main argument for **school choice programs.**
- **Schools are not only restricted in their selection of production plans but also in their inability to charge different rates for different levels of educational quality.**

- Price differentiation is not a possibility for many schools. They can not approach parents and ask, “What quality of education do you demand for your child? We have three options available— low, medium, and high quality. Our prices increase with quality.” Instead, all families pay the same price regardless of how much quality they consume.
- However, **the quality of education received by different students within a school may vary even though they all ‘paid’ the same price.** Some teachers are better than others. Some students are smarter than others. **School policies, such as ability tracking, may implicitly serve students a quality of education that the school thinks their parents demand or that the students’ “deserve”.** The inability to charge different rates restricts the school’s ability to purchase a variety of inputs to best educate the array of students it must serve.



# Competitive Markets

- Competitive markets are frequently credited with **keeping prices low and increasing productivity.**
  - Economic production theory **assumes firms face competition from other firms in both the input and output markets.**
  - In a competitive market, **all firms would be looking for means to improve their product's quality and attract a larger share of the consumer market.**
  - It is for this reason that **we frequently credit competitive markets as the source for innovations in product design and productive technology.**
  - In competitive markets, **firms are always searching for a competitive edge that will increase their sales and profits.**
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Three key aspects to competitive markets:

- Firms compete with each other for access to productive goods in the **input markets**
- Firms compete with each other for customers in the **output markets**
- **No barriers to entry and exit** in any firm

- Critics of publicly-funded schools **often refer to the monopolistic power these schools wield in the market.**
  - As a result of their monopolistic power, **the cost the public must pay to operate the schools is too high and the quality of the education produced is too low.**
  - They argue that school choice programs would create a marketplace for schools in which schools would need to compete with each other for students and the funding that comes with them.
  - Prices would fall, quality would increase, and consumers would be better off.
- Technically, **schools are not monopolies.**
  - **They face competition in both the input and output markets.**
  - **The magnitude of this competition is lower than that in many private sector industries and lower than supporters of school choice want to create.**

## CONSIDER THE COMPETITION SCHOOLS FACE IN THE INPUT MARKETS FOR STUDENTS AND TEACHERS, THEIR TWO MAIN INPUTS

- Most students **are assigned to schools based on where they live** rather than schools competing with other schools for students.
  - There may not be competition among publicly- funded schools for students, **there is competition between public and private schools for students.**
  - This competition **tends to be narrow in scope** with the schools competing for the most academically able students and those from families with the resources to afford a private education.
  - Hence, while schools face competition in the input market for students, it is **not as broad- based as it is in the input market for teachers.**
  - Schools **face competition for teachers.** Sometimes this competition is so great that schools have difficulty attracting competent teachers.
  - **A teacher's skills and knowledge** can be applied productively in many firms other than schools.
- A writing teacher can be employed as a copy editor for a publishing firm; A physical education teacher could work for a community's recreation department; Numerous firms have demand for the skills and knowledge of math and science teachers.

- The product schools take to the output market to sell is the quality of the education they provide to students.
- **Who consumes this education?**
  - It is appropriate to conceptualize **families**, not the students themselves, as the consumers of education.
  - **Families determine where to reside which for many determines which school their children attend.**
  - Families also assess whether or not they can afford to pay tuition costs at private schools. If families do not value the education a school provides, they will either choose to live elsewhere or send their children to a private school.
- In this sense, there is a degree of competition in the output market for education.

Economists also view post-secondary education institutions and business as consumers of education.

- If institutions of higher education view the quality of education provided by a certain school as substandard, they will be hesitant to admit its graduates.
- Low college enrollment rates, in turn, become a quality measure on which families select residential locations and whether to send their children to private schools.
- Business demand workers who possess a specific set of skill and knowledge.
- If students graduate with substandard skills and knowledge, businesses will be hesitant to hire them.
- Or if they do hire them, the firms will have to spend money and other resources to provide these students with appropriate training, thus increasing their costs of production.
- Poor career placement and trajectories of a school's graduates also factor into a family's education consumption decisions.

## Several barriers for schools to enter and exit the education industry

- Profits in education are generally very little to non-existent making the creation of new schools unlikely.
- Public funding for the construction of new schools is limited.
- With regard to exit, schools are integral parts of communities.
- Even when dwindling enrollments may prove school closure to be appropriate economically, communities are willing to wage fierce fights to prevent their schools from closing.
- Exit from the industry is often therefore politically infeasible.
- Compulsory attendance laws pose another barrier to exit. If a school closes, those students must be placed in other schools which may not have the physical capacity to accommodate them.

- Schools do face a degree of competition in both input and output markets, but that there are significant barriers to entry into and exit from the educational industry.
- Given these conditions, economic production theory would predict that the cost of education is higher than it ought to be, quality below what it ought to be, and the speed of innovation and technological advance slower than it could be.

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