USING ARROW DIAGRAMS TO UNDERSTAND CLAIMS

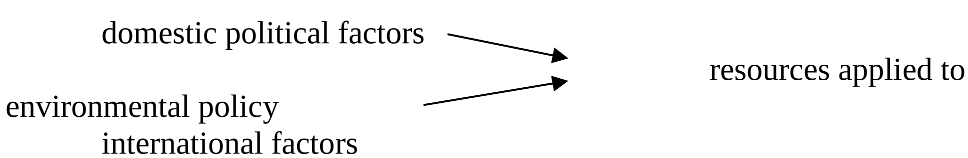
M.J. Peterson

Whether you are trying to understand someone else's argument or are formulating your own, arrow diagrams can help you keep track of the claim whenever the claim involves a statement of relationship. You do not need an arrow diagram to understand a **factual claim**, such as "it snowed last night" or "Harry Truman won the 1948 presidential election." Factual claims are self-contained statements that are either true or false. However, arrow diagrams are very useful when dealing with a **relational claim.** A relational claim is more complicated than a factual claim because it consists of a one or more part assertion connecting two or more elements. A one-part relational claim says that some **consequent** (the event, condition, or situation observed later) follows from an **antecedent** (the event, condition, or situation observed earlier). In a two-part relational claim, the antecedent and the consequent are linked through an **intermediate factor**, some other event, condition, or situation that connects them.

Simple Arrow Diagrams

It is easy to keep track of a one-part relational claim linking a single antecedent to a single consequent, so an arrow diagram is not really necessary. Nor does one save much space in an essay by presenting such a claim (like "high inflation leads to more unemployment") in an arrow diagram (high inflation → more unemployment).

Arrow diagrams start becoming useful when a one-part relational claim links three or more elements. For an example, take Paul Steinberg's claim that "the resources brought to bear on environmental policy in developing countries are of two types: those closely associated with a given domestic political system and those whose essential productive dynamic resides beyond that society's borders" (*Environmental Leadership in Developing Countries* (2001), p. 7). This claim has two antecedents and one consequent, and an arrow diagram makes it more visible:



Arrow diagrams are even more useful when dealing with two or more part claims that include intermediate factors. The intermediate factor may by a second event, condition or situation that follows the first and appears before the third occurs. When an intermediate factor is present, the arrow diagram shows a chain of three factors:

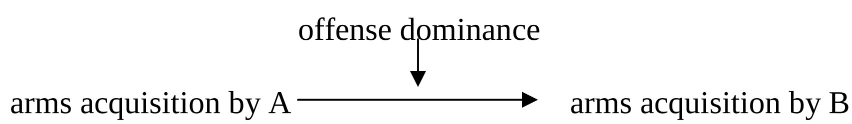
antecedent → intermediate → consequent

This is the basic form of claims that ample food supplies eventually lead to "overpopulation" (in the ecological scientists' definition as a population more numerous than can be fed adequately with available food supplies):

plentiful food → increased birthrate → overpopulation

Noting the intermediate factor separately is important because it reminds us that plentiful food alone does not lead to overpopulation. If a particular group of humans shares a strong social norm limiting the number of children each couple has even in times of plenty, good harvests will not trigger additional childbearing. This would be the result if most people in a particular area lived by the Zero Population Growth slogan "stop at two."

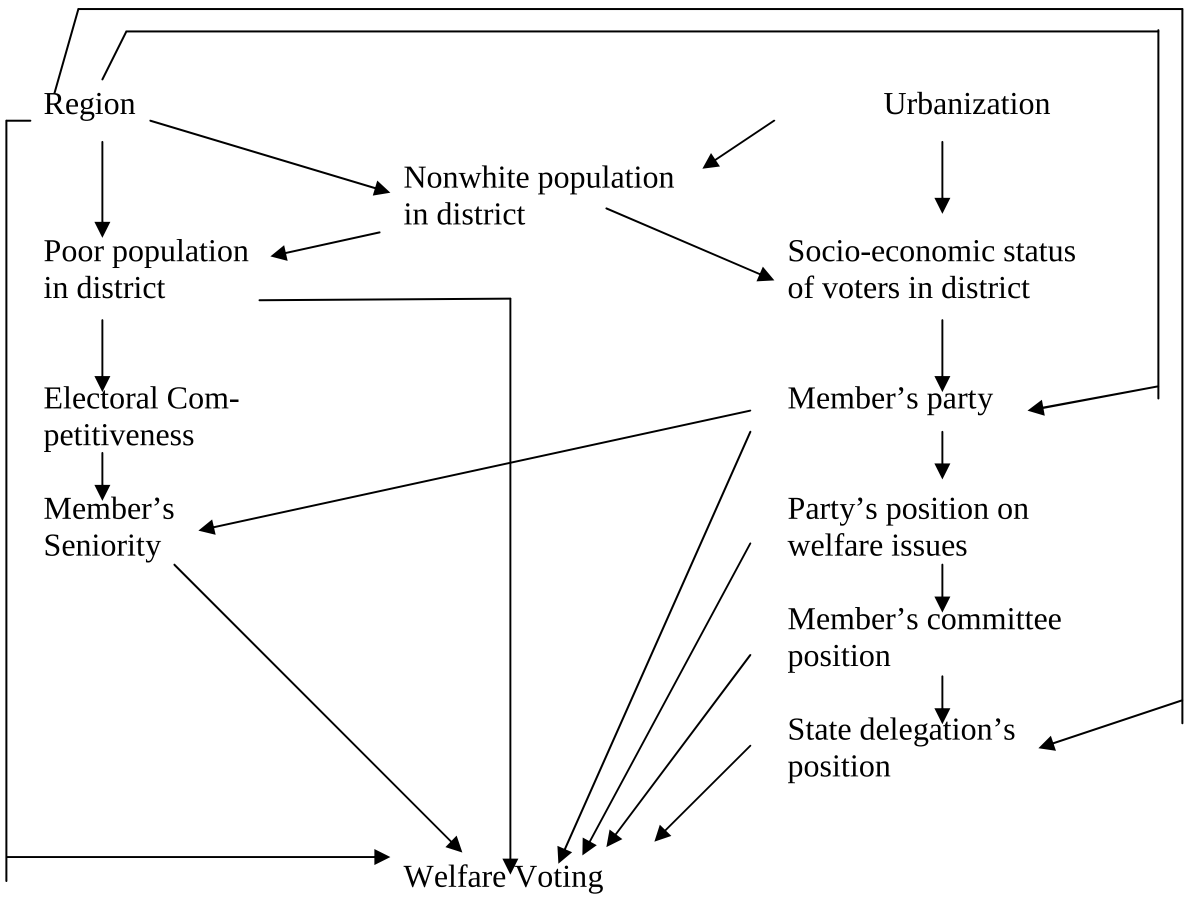
A different style of arrow diagrams is used to summarize claims when the intermediate factor is an **intervening factor** – an event, condition, or situation that does not follow from the antecedent, but does combine with it to yield the consequent. The basic argument of strategic analysts using the concept of the "security dilemma" is that an increase in defense spending by one great power is much more likely to inspire rival great powers to increase their own defense spending when military technology and organization make offensive strategies (based on attacking first) more advantageous than defensive ones (based on withstanding attack). They refer to this condition as "offense dominance" and their argument can be diagrammed as



This notation reminds us that the strength of the link between antecedent and consequent is affected by the presence of the intervening factor. In the security dilemma, presence of offense dominance means high likelihood that arms acquisition by A will lead to counter-acquisition by B while absence of offense dominance means low likelihood

Arrow diagrams can become as complex as an analyst desires. In 1984 Richard C. Rich summarized his findings about the factors that influence the likelihood that a particular member of Congress will vote in favor of establishing, maintaining, or extending welfare programs. His overall claim includes seven lines of direct causation and four of indirect causation, with the additional complication that one indirect cause (nonwhite population) figures in two of the lines of causation while two (region and member's party) show up both as a direct cause and as an indirect cause. Rich is clearly a firm believer in the notion of **multiple causation**, the idea that any event, situation, or outcome can have more than one cause, or that several things must converge at the same time to produce an outcome.

Here is his complete arrow diagram:



From Richard C. Rich, "The representation of the poor in the policy process: Changes in Congressional support for welfare," in Robert Eyestone, ed., *Public Policy Formation* (Greenwich, CT: JAI Press, 1984), p. 135.

Types of Claims

Arrow diagrams can be used to track both types of relational claim found in political arguments and social science research. The first type of claim asserts **correlation –** that when we see an antecedent event, condition, or situation we will soon see the consequent event, condition, or situation. A claim about correlation is simply a claim that two things appear so often so close together in time that seeing one is a signal to expect to see the other. Humans often operate very successfully on correlational knowledge. Long before people understood weather systems (for instance, how "cold fronts" and "warm fronts" develop and affect weather conditions), they realized that some types of clouds are more likely to result in rain than others. They then used their classification of clouds to guide decisions about when they could stay outdoors and when they should take shelter to avoid getting soaked.

Correlational claims say that certain things appear together, but do not say why they appear together. However, people often want to know why the things appear together. That is, they want to understand what **causes** a consequent. Causal claims are stronger than correlational ones. They do not stop with saying that the consequent comes after the antecedent, they go on to say that existence of the antecedent triggers occurrence of the consequent. We can appreciate the difference between correlation and causation by thinking about changes in how humans talk about the daily cycle of the sun. For as long as humans have existed on Earth, they have noticed that the sun comes up on one side of the local landscape, crosses the sky, and goes down on another side (designated "east" and "west" respectively in modern English). Using chronological reasoning, it was easy to attribute lightness and darkness to the presence or absence of the sun in the sky. This would yield the simple arrow diagrams

sun in sky → light and sun not in sky → dark

Or, if they wanted to combine the two statements, they could use

alternation of sun/not sun → alternation of light/dark

However, humans were never satisfied with this correlational knowledge; they also wanted to understand why the sun moved through the sky. This was true even among those who did not think life would be more convenient if natural light was available 24/7, but I would not be surprised if those who wanted more hours of it were the ones most actively thinking about why the sun disappears.

Coming up with an accurate causal explanation of the sun's daily movement was not easy because humans do not feel the rotation of Earth. Humans think they are staying in one place when they stand still, and this sensory information encouraged people to conclude that the sun is moving. Each culture came up with its own explanation of why the sun moves, usually involving some story about a sun god or some force that drives it across the sky each day, sends it underground, and repeats the trip the following day. Though at least some humans understood even in ancient times that the Earth is roughly spherical, human ability to observe motion did not improve sufficiently to allow proving that the Earth rotates until the seventeenth century CE. Humans today (at least those who learn some modern natural science) understand that both the Sun and the Earth move, but that Earth's rotation is what produces the daily pattern of sunrise, sun providing light as it crossing the sky, sunset, and darkness. This changed understanding shifted the causal statement from

movement of Sun → daily light/dark alternation

to

rotation of Earth → daily light/dark rotation

This example points up one of the basic methodological rules shared by natural and social science: **correlation is not causation**. Finding a correlation gives us good reason to start searching for causes because a correlation does indicate that antecedent(s) and consequent(s) are related in some non-random way.

We need to be careful, though, because the antecedent of the correlation may not be the antecedent of the causal relation. That was clear in our sun argument. The same problem of correlational antecedents not being causal ones often comes up in political argument. An observer may notice that in City A only 10% of high school graduates go to college while in City B 40% go. Most of us would not leap to the easy conclusion that the difference is produced by the city as a whole. We would tend to look for some characteristic of the cities' environments or respective populations that differed between city A and city B, and attribute the variation to that characteristic (relying on the broad warrant that similarities explain sameness and differences explain variation).

Few people today would attribute the different rates of college-attendance to the cities' location or climate, though there is a long history of assertions that climate or topography affects a people's character. One such assertion is that persons who live in mountainous regions where people need to fend for themselves more have a stronger innate love of freedom than lowland dwellers. Another is that persons living in tropical climates get weakened by the heat and are therefore less energetic than those living in temperate climates. Today analysts would be more likely to derive ideas about the relevant differences between the cities from sociological and economics theories, and look at things like the quality of the two cities' school systems, whether high school students in each city have advisers who stress college as an option, the average income of persons or households living in each city, the racial/ethnic composition of each city, or the availability of jobs that do not require college in each.

You may have noticed that I have been using the same graphical notation of arrows to indicate both correlational and causal claims. In most political arguments this is not a problem because everyone is trying to make, and therefore diagramming, causal claims. If you need to deal with both types of claims and want to keep them separate, use a distinct notation (way of writing) for each. You could, for instance, use an arrowhead (>) for a correlational claim and a complete arrow (→) for a causal one. In a complicated arrow diagram (something like the Rich claim diagrammed earlier), you might use a light complete arrow for a correlational claim and a bold one for a causal claim.

Some Useful Terms

Antecedents and consequents can be **binaries –** things that either exist or do not, **categories –** things that occur in distinct types such as gender or religion, or **variables –** things that can take any of a number of measurable or countable values such as income, population, size of armed forces, or number of legislative seats won in the most recent election.

When causal arguments involve antecedents and consequents that are variables, it is common to refer to the antecedent as the **independent variable** and the consequent as the **dependent variable**. This makes sense, since a causal argument is a claim that the consequent exists because the antecedent is present. This does suggest a one-way argument, that the existence of the consequent depends on the antecedent but the existence of the antecedent does not depend on the consequent. However, many relations in social sciences have **feedback effects** in which the emergence of the consequent alters the antecedent in some way. Social scientists have various ways of dealing with this phenomenon of **reciprocal causation**. Some ignore it (earning them scorn from peers who believe it exists); some disaggregate a reciprocal relation into phases, starting by treating element A as the independent variable and then turning to treat element B as the independent one; some avoid designating variables as “independent” or “dependent”.

Types of Causal Relationships

Correlations are all pretty much the same; they indicate that the antecedent and the consequent appear together. They differ only in the timeframe involved. The two elements might appear simultaneously; the consequent might appear after a short lag, or it might only appear after a longer lag (though too long a lag will lead people to miss the correlation altogether).

Causal relations are more complicated. A causal relation may go only one way

$$A \rightarrow B \quad \text{or} \quad A \rightarrow B \rightarrow C$$

But some are reciprocal relations

$$A \longleftrightarrow B$$

The term “cause” (whether used as a noun or as a verb) covers several ways that the consequent (C) can be related to the antecedent (A). When researchers want to describe a causal relation more precisely, they use one of several related phrases:

Necessary cause (or necessary condition): an event, situation, or condition that must be present for the consequent to occur. Whenever it is absent, the consequent does not appear. Logicians summarize this in the phrase *If not A, then not C*

Sufficient cause: an antecedent always followed by the consequent. This means that any time the sufficient cause if present, the consequent will occur. Logicians summarize this in the phrase *If A, then C*. Both in nature and in human interaction, “the” sufficient cause is often a cluster of antecedents occurring simultaneously. The sufficient cause of fire is a combination of three things – a spark, flammable material, and oxygen – because all three need to be present at the same time for fire to start. Most rules about eligibility to vote have a sufficient cause made up of three elements – a minimum age, status as a citizen of the country, and a minimum period of residency in the particular town or area where the would-be voter wants to vote.

Contributory cause (one type of intervening variable): an antecedent that makes emergence of the consequent more likely. The increase does not have to create certainty that the consequent will occur, it only has to increase the frequency with which the consequent appears when the contributory cause is absent. In logicians' notation, *If A, then C is more likely*. Many of the standard theories guiding the study of voting behavior involve contributory causes. For instance, the one saying that people with higher income are more likely than those with low income to vote for a conservative party more likely. Seeing income as contributory rather than sufficient aligns with our individual experiences of knowing some high-income people who do not vote for conservatives and some low-income people who do.

Alternative cause: any one of a number of antecedents that result in appearance of the same consequent. In logicians' notations, *If A1 or A2 or … or An, then C*. Using another voting behavior example, researchers know that a voter's income, parents' political affiliation, and own political ideology are all possible causes of voting for a particular party in a given election. Each alternative cause can be either sufficient or contributory; the important analytical point is that there is more than one way to get the same consequent to emerge.

Contingent condition: an event, situation, or condition that modifies the effect of a contributory cause. In logicians' notation *If Cont, then A, then C*. Student of voting behavior continue to observe that black and hispanic adults vote are less likely to vote than white adults. When, however, they break down their sample by level of education, they find that highly-educated blacks and hispanics are more likely to vote than highly educated whites. Thus race, which is often treated as a consistent contributory cause, turns out to have different effects depending on level of education.

Proximate cause: when a chain of causation has an antecedent and one or more intermediate elements leading to the consequent, the intermediate element immediately preceding emergence of the consequent is called the proximate cause. Thus historians often refer to the particular diplomatic crisis that occurred in July 1914 is the proximate cause of World War I.

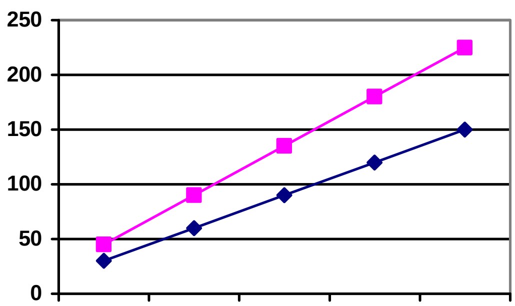
Remote cause: a term covering the initial antecedent and all but the last intermediate in a multi-link causal relationship. For historians, the various rivalries among the European great powers that developed after 1815 and the prior crises that were settled for the moment but fed the rivalries are the remote causes of World War I.

Causal relations can take any of several forms depending on how the antecedent affects the consequent:

Direct: the antecedent and the consequent change in the same direction. Thus, an increase of A produces an increase of C, or a decrease of A produces a decrease of C. Thus someone saying there is a direct relation between income and health is arguing that in some way (through an intermediate condition of access to healthcare) higher income causes better health and lower income causes worse health.

Inverse: the antecedent and the consequent change in opposite directions. Thus, an increase in A produces a decrease in C, or an decrease in A produces an increase in C. For example, increased availability of vaccines decreases the prevalence of the disease they protect against. After the Salk and Sabin vaccines were invented in the 1950s, the number of polio cases decreased (over a few years) to zero in the US.

Linear: the value of the consequent changes by the same amount for each additional unit of antecedent added or subtracted. For example, a promoter charging $30 a ticket for admission to a rock concert gets $30 when 1 ticket is sold, $90 when three tickets are sold, and $900 when 30 are sold. Obviously a promoter who has access to a stadium could get $90,000 by selling 30,000 tickets. Linear relations can be more or less "steep" depending on how many units of change in the consequent are caused by each unit of change in the antecedent. The prospects of a promoter selling tickets at $45 each will be graphed with a steeper (more sharply rising) line than those of the promoter selling tickets at $30 each, as you can see from the two lines on this graph:

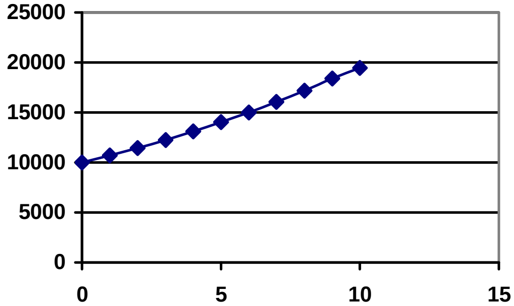


Exponential: the value of the consequent changes by a percentage rather than by a fixed unit amount. This sort of relation is common with changes that can be expressed in averages or percentages. The most common example is investments; investing $100 in a stock earning 7% a year for several years would yield $7 the first year for a new total of $107. Reinvesting the whole income, the resulting $107 would yield $7.49 in year 2 for a total of $114.49. After 10 years of reinvesting the income and a steady 7% return (yes, an optimistic scenario), the total would be $194.70.

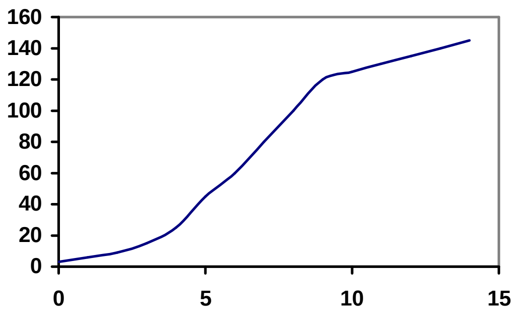
Human population growth is also an exponential relation. Likely population growth is estimated by determining the current fertility rate of a population – the average number of children born to each woman of child-bearing age, and multiplying the number of women of child-bearing age by that number. A fertility rate of 2.1 is the "replacement rate" – the amount of childbearing that will just replace the current generation. (It is 2.1 because some women do not live long enough to have children and women who do live to sexual maturity but never have children are included in the total number of women of child-bearing age.) A fertility rate lower than 2.1 means the population will become smaller over time unless there is net immigration into the area. A fertility rate higher than 2.1 means an increase over time. Since fertility – like dividends on investments –

compounds, a society will have a smaller population in 2100 if its fertility rate during the entire 21st century is 3 than if it is 4. Population discussions can also be expressed in terms of percentage increases rather than fertility rates. This is the form of recent discussions among political Islamicists about how Islam will come to dominate the world because populations in many Moslem countries are currently growing at higher percentage rates than populations elsewhere.

Exponential relations appear on graphs as curves:



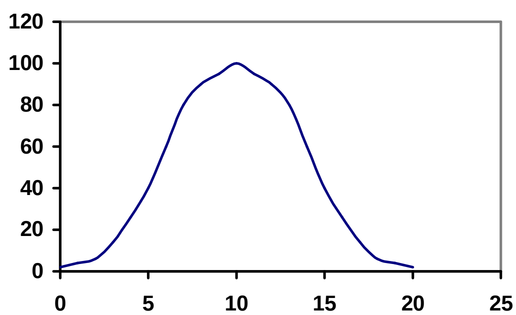
S-curve: the value of the consequent increases at different rates as the value of the antecedent rises. At low levels, the increase is modest. The increase shifts to a more dramatic rate at some intermediate level, then shifts again to a more modest rate at some higher intermediate level. This relation is called an S-curve because its graph more or less vaguely (depending on the data) resembles a tilted letter S:



The growth and decline of fads, epidemics, and the spread of successful new technologies show this pattern. Initially, only a few people adopt the fad, have the disease, or acquire the technology. Even if they talk it up to their friends and the friends also adopt it (fads, technologies) or they spread their germs (diseases), the number of people learning about it or getting the germs is fairly small. At some point, however, the number of adopters (fads, technologies) or sick (diseases) starts increasing faster because the larger number of adopters or sufferers have contact with more other people. Now more and more people are adopting or catching, so the spread of the fad, technology, or disease speeds up. Yet, since there are only so many people in a population, the increase has to slow down at some point because most people have already acquired (fads, technologies) or caught (disease) and fewer are left who have not. With fads, this tapering off point it is a point of boredom well short of 100% of the population. With diseases and technologies the ultimate limit is 100% of the population (whether measured by individual, as with iPods, or by household, as with washing machines) but actual spread usually ends before 100% because most societies have a number of people willing to forego a particular technology or able to resist a particular disease.

Thus in an S-curve pattern, an initial period of low growth is followed by a period of high growth is followed by a period of low growth. This can be confusing in the early stages because it is easy to see an exponential relation where there is actually an S-curve one. Mistaking one for the other will lead to bad predictions. The only way to avoid confusion is pay close attention to the data so you can pick up the inflection points (the points where the rate of increase changes) on the S-curve. This may not be easy at the lower inflection point, but will be clear fairly soon on the higher one.

Bell-shaped Curve: a bell-shaped curve looks like the "normal distribution" with which you may be familiar from statistics. It can also be thought of as an S-curve connected to a mirror image of itself:



Bell-shaped curves do summarize some patterns found in nature and politics. They are often seen in environmental arguments because they graph out what ecologists call "overshoot." Recall the claim arrow diagrammed earlier that ample food leads to increased births that in turn leads to overpopulation. The bell-shaped curve traces out Thomas Malthus's famous assertion (in *An Essay on the Principle of Population*, 1803) that human and animal populations always grow beyond the numbers that can be fed, and correction comes in the form of mass starvation and/or disease until population levels decrease to the point that food supplies can support them again. Uncontrolled or poorly controlled fisheries today show the same pattern; rising catches as fish are found and more boats go after them, and then collapse if the rate of fishing exceeds "sustainable yield" – a rate of fishing on adult fish only that permits the fish population to reproduce itself.

Threshold Change: a discontinuous change that yields a one-time sudden large shift in the value of the consequent. This type of change is particularly hard to anticipate. A causal relation may seem to show a linear or an exponential pattern as the value of the independent variable changes, but then leap upward or downward when the value gets to some level. Such changes may be one-time events after which the relation returns to its previous pattern. They may be one-time events that yield a change of pattern followed by stabilization and persistence of the new pattern. They may be cataclysmic events – nuclear winter for example – that end or fundamentally transform existence. Threshold changes do not figure prominently in predictive political argument, but do turn up in after-the-fact discussion of revolutions, serious policy fiascos, and other big changes.

Complex Arrow Diagrams

Complex arrow diagrams can differentiate between direct and inverse relationships, deal with two-way relations, trace out one-way or two-way relationships affected by intermediate or intervening factors, and identify more complex feedback effects among several interacting factors.

Some users of arrow diagrams distinguish between direct and inverse relations by using a plus sign (+) for direct relationships and a minus sign (-) for inverse ones. This can be confusing, though, because + can also be understood as meaning "positive" or "a good thing" and – as meaning "negative" or "a bad thing". I prefer to use the first letter; lower case d for a direct relationship and lower case i for an inverse one. This is a very useful extension of arrow diagrams for political arguments because it helps participants keep track of self-reinforcing and self-limiting dynamics. The arrow diagram rule for identifying these is that when you have a multi-factor relationship and the number of inverse links in it is zero or even, the overall relation is self-reinforcing and will intensify over time. When the number of inverse links is odd, the dynamic is self-limiting.

In the 1970s and 1980s many analysts asserted that fertility rates are inversely related to average income. Some development economists used this to argue that economic development would avert population explosion. Simultaneously, some environmentalists argued that many developing countries would fall into a "demographic trap" because the pressure of their current population on the environment would limit increases in income, keeping them below the point where people start having fewer children. Their claim could be arrow diagrammed as follows:

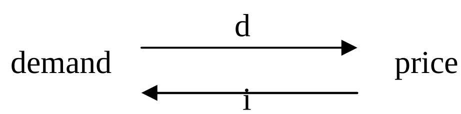
and yields an even number (2) of inverse relations.

Economic policy arguments also provide examples. These tend to start from standard economic analysis of how (other things remaining steady) supply and demand interact to affect prices. More specifically, economists agree that:

If supply remains steady, a rise in demand triggers a rise in price and a fall in demand triggers a fall in price

If supply remains steady, a rise in price will trigger a fall in demand and a fall in price will trigger a rise in demand.

We can arrow diagram this two-way relation between prices and demand as:



With an odd number (1) of inverse relations in the cluster, the dynamic is self-limiting.

In each case, we can use the arrow diagram to think about possible policy interventions. If faced with a self-reinforcing dynamic that we believe has bad consequences, we probably want to find a way to break the spiral. One approach would be to consider how we might eliminate or reverse one of the inverse relations within it. In the environmentalist four-variable argument about population just discussed, this would suggest working on either the relation between environmental stress and income or the relation between income and birthrate.

Though the demand-price relationship is self-limiting, we might want to use our economic knowledge to help attain some policy goal, for instance reducing fossil fuel use. The demand and price diagram suggests two sets of policy possibilities – actions that directly reduce demand and actions that indirectly reduce demand by increasing price.

Use the space below to diagram some fuel policy ideas for discussion in class.