Poverty Traps and Appalachia

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1. Introduction

In this chapter, I provide some general ideas on how to conceptualize poverty traps and speculate on their applicability to understanding Appalachian poverty. My goal is to stimulate thinking on Appalachia that exploits contemporary perspectives in economics on the sources of persistent poverty and inequality. To do this, I focus on both the theory of poverty traps as well as issues in the econometric assessment of their empirical salience. While I will describe different definitions of poverty traps below, all of these definitions have the common feature that poverty, be it for a family, a community, or a larger aggregate, is highly persistent. In other words, one cannot expect contemporaneous poverty to simply correct itself, except over very long time horizons, if at all.

Why should poverty traps be of particular importance to policymakers? One reason for why poverty traps are of particular importance is that they can provide a *prima facie* justification for government interventions on equality of opportunity grounds. John Roemer has argued persuasively that equality of opportunity requires that individual socioeconomic prospects not be affected by factors of which an individual has no control; this perspective provides a way of integrating personal responsibility into the assessment of equality of opportunity.[1] Durlauf (1996b,2006) has applied Roemer's reasoning to provide a justification of government interventions when poverty traps are present. The ethical justification for interventions is most obvious if one considers the future socioeconomic prospects of its children. Following Roemer's logic; it is self-evident that children are not responsible for the environments in which they grow up, whether at a family or a community level. While some subtleties exist in translating this lack of responsibility into an ethical case for government intervention (for example one needs to address the rights of parents to provide differential opportunities for their children), it is fair to say that the presence of a poverty trap provides a prime facie case for government intervention.

By itself, the ethical case for government interventions implied by equality of opportunity or other considerations is inadequate for policy evaluation. A poverty trap generated by deficiencies in early childhood development calls for very different interventions than one

[1]See Roemer (1998) for an overview of his work.

caused by features of a regional labor market. Hence, a satisfactory theory of poverty traps needs to account for mechanisms as well as the basic facts of poverty persistence.[2]

One natural reason why families in a community may collectively appear to be in a poverty trap is that the individual families suffer from similar initial conditions that produce a poverty trap via family dynamics. In my development of poverty trap definitions I will start with family based models and later incorporate community factors.

My discussion reflects the large body of modern literature on persistent poverty and poverty traps; this modern literature tends to focus on determinants of poverty that are generated at a higher level of aggregation than the family; although as we shall see the mechanisms that produce poverty traps in the modern literature can do so in family based models. One aspect of this modern literature has focused on national economies, in order to understand continuing levels of deprivation in much of the world. Azariadis and Stachurski (2005) is a survey of poverty traps in development and economic growth. The focus of these papers is typically on how an entire nation can be trapped in poverty. A second aspect of the modern literature has focused on how persistent poverty can emerge among a subpopulation in affluent countries such as the United States. Ghettos are a canonical example of a neighborhood level-poverty trap. The neighborhood effects literature is quite diffuse; see Lang (2007) for a recent overview of the poverty literature and Durlauf (2004) for a focused review of persistent poverty from the vantage point of neighborhood effects and their attendant effects on inequality.[3]

Regions per se do not represent the usual scale of aggregation at which poverty traps are studied in modern research. In considering a context such as Appalachia, one sees elements of both economy-wide and local poverty traps. By this, I mean the following. Taken as a whole, Appalachia is poorer than the rest of the United States and so, given its size, one might be tempted to ask whether the mechanisms that produce national poverty traps apply to the region. On the other hand, conditional on this relatively weak economic performance of the region, there is substantial heterogeneity across Appalachia. Central Appalachia in general and Eastern Kentucky in particular appear much closer to poverty traps than the rest of the region.

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[2]I thank James Ziliak for this argument.

[3]Jencks and Mayer (1990) is a survey of social science research that precedes the modern economics literature. See also Manski (2000) and Durlauf and Ioannides (2010) for surveys of social interactions models, which focus on how groups affect individuals.

While I am not aware of any modern research in economics that explicitly studies Appalachia from the perspective of poverty traps, ideas closely related to poverty traps have long been associated with the region. Over 30 years ago, Billings (1974)[4] described standard thinking on Appalachia:

> The culture of poverty is the most common theory in the literature on poverty and Appalachia alike…Culture of poverty explanations, when applied to Appalachia, take several forms…Emphasis is on the debilitating effects of an atavistic, frontier culture and the socialization of its people into backwardness. The subcultural claim is often buttressed by an assertion that, with the recent introduction of improved roads and mass media, Appalachia is experiencing its first contact with the outside. (315-316)

Eller (2008) further argues that culture of poverty arguments helped motivate war on poverty strategies for Appalachia. One use of these notes, I hope, is to provide a guide to quantitative versions of culture of poverty arguments which can both clarify theoretical thinking as well as provide insights into how one can assess their empirical salience.

One important feature of modern poverty theories, whether defined at the aggregate or individual levels, is their emphasis on the interplay of a range of causal factors in producing (or eliminating) a poverty trap. This richness comes at a price as the empirical evidence for any particular factor is consequently difficult to assess. On the other hand, this richness is important in developing poverty trap perspectives that respect the heterogeneity of individual and subregional outcomes within Appalachia.

Income dynamics and poverty traps

In this section, I outline some baseline models of income dynamics and assess their equilibrium properties from the vantage point of trying to define a poverty trap. The reason for proceeding this way is that there is no accepted formal definition of a poverty trap. Rather, the term encompasses, I believe, three logically distinct, although mutually compatible, qualitative claims about the nature of poverty:

[4]Billings argues cultural explanations are overstated, a position maintained in Billings and Blee (2000).

i. poverty is highly persistent,

ii. poverty can be perpetuated indefinitely either across an individual's life or across generations within a family dynasty,

iii. poverty is perpetuated by certain features of the socioeconomic environment that are outside an individual's control so that two individuals (or family dynasties) with identical preferences could end up with different degrees of socioeconomic success.

The absence of either a unique and precise qualitative definition of a poverty trap does not, in my view, make the term unhelpful.[5] In contrast, in my view formal definitions of poverty traps are useful to the extent they capture aspects of these qualitative ideas. One important distinction between poverty trap concepts i and ii as opposed to iii is that first two concepts refer to properties of the time series process for income whereas the third refers to the mechanisms which underlie the income process. What sorts of aggregate or collective mechanisms fall under iii? For the Appalachian case, one obvious example is the state of the coal industry. As this industry declines, so do wages and so Appalachian poverty emerges as a consequence. This type of explanation may be contrasted with the idea that a given region is associated with social norms that reduce the value attached to education; a claim of this type is consistent (though certainly not proved by) the low educational attainment of Appalachian adults compared to the rest of the United States. These types of influences are often known as social interactions or neighborhood effects; I use the term social interactions here.

For expositional purposes, I focus on models of intergenerational income dynamics and so do not address issues of intragenerational poverty traps. Focusing on intergenerational income dynamics minimizes the need for formalism to illustrate qualitative ideas. My objective in developing concepts of poverty traps and persistent poverty is to translate qualitative ideas into mathematical equivalents. These mathematical equivalents are of intrinsic interest in terms of clarifying qualitative ideas, but are also important as they provide a segue between qualitative

[5]For example, the lack of a precise single definition for poverty traps does not inhibit evaluating whether a given case is a poverty trap. Following an example in Taylor (1998), the absence of a clear definition of money does not diminish the meaningfulness that a dollar bill is an example of money.

notions of poverty traps and persistent poverty to statistical work on both the measurement and the determination of the mechanisms by which they are generated.

Formally, intergenerational models of poverty traps are constructed by considering the dynamic behavior of a population of family dynasties; these are indexed by i. Issues of intermarriage, fecundity, etc. are ignored so each generation of the family is a single individual who lives 2 periods. The pair of indices i,t denotes the adult at time t in dynasty i, so person i,t was born at $t-1$; incorporation of a more elaborate lifetime structure does not matter qualitatively. This structure is known as an overlapping generations model and is, since Becker and Tomes (1979), the standard mathematical structure for thinking about intergenerational income dynamics. The framework, despite its many abstractions, allows one to focus on the way in which socioeconomic status at adulthood is determined by childhood versus adulthood factors.

Throughout the analysis, adult income is denoted by $y_{i,t}$. While income does not summarize an individual's socioeconomic status, even in this very stylized framework, it will be the basis of measuring whether or not the person is in poverty. For simplicity, poverty is defined by an income less than or equal to y^{POV}. The level of $y_{i,t}$ relative to y^{POV} determines whether whether family i at time t is in poverty, and hence, by tracing out the dynamics of the relationship between the poverty level and the income level of different generations, allows one to discuss the degree of persistence of poverty for a given family dynasty and thus to make formal what one means by a poverty trap. Notice that one can engage in comparable exercises for measures of socioeconomic status other than income.

Family-based Models

One view of intergenerational income dynamics is family-specific in that parental income determines offspring income. The formal analysis of this type of model was pioneered by Becker and Tomes (1979) and Loury (1981). A deterministic version of this class of models produces the simple law of motion for family income

$$y_{i,t} = \varphi\left(y_{i,t-1}\right). \tag{1}$$

In words, parental income $y_{i,t-1}$ determines offspring income $y_{i,t}$. The key mechanism in the classical models of this type is that parental income determines human capital investment in children, which in turn determines future adult income. Recent work by James Heckman, e.g. Heckman (2008)[6], has emphasized the role of parenting in the production of personality traits such as conscientiousness that are distinct from cognitive skills. Further, one can generate persistence of income via persistence in the heritability of intelligence, which has been a longstanding concern. Eq. (1) elides these distinct sources in order to minimize notation for the basic definitions I wish to develop, but they are essential to account for in empirical work if one is to develop policy responses to poverty traps, for reasons argued above.

This model, and variations such as eq. (4) below which allow for uncertainty, represent the workhorse for economic models of intergenerational mobility. It is standard (and trivial) to assume that $\varphi(\cdot)$ is nondecreasing in y, which means nothing deeper than that higher income of parents does not reduce the income of offspring. As this model is assumed to apply to all members of the population, the equation is sufficient to describe the evolution of the complete cross-sectional distribution of income over time, and therefore allows one to characterize the poverty rate, measures of inequality and other population-wide aggregates. Given a cross section distribution at time t, the function $\varphi(\cdot)$ determines what the cross section distribution will be at time $t+1$.

From the vantage point of an individual family dynasty, an immediate implication of this structure is that for every initial condition $y_{i,0}$, income will exhibit one of two long run behaviors. Formally, as t goes to infinity, $y_{i,t}$ will either converge to a limiting value, i.e. some finite level of income y such that $y = \varphi(y)$, or diverge to infinity. These are the steady states of eq. (1). Ignoring the latter possibility (which only adds technical complications at this point), the long run properties of the income dynamics process are fully summarized by the steady states of eq. (1).

Multiple steady states provide one formalization of the concept of a poverty trap. To see why, consider the behavior of differences in income between two family dynasties i and j, i.e.

[6]See Almund, Duckworth, Heckman, and Kautz (2011) for a comprehensive survey of what is known about the effects of personality of economic outcomes.

$y_{i,t} - y_{j,t}$. If eq. (1) is associated with a unique steady state, then it is immediate that regardless of the value of the difference in incomes today, this difference will eventually disappear:

$$\lim_{T\to\infty} y_{i,t+T} - y_{j,t+T} = 0. \tag{2}$$

In words, the uniqueness of a steady state implies that any contemporaneous inequality will disappear over time. While the convergence to the common long run income level may be slow, it will inevitably occur.

In contrast, suppose that there exist multiple steady states. Further, assume that these steady states are locally stable, which means that if a family starts sufficiently near either value, it will converge to that value. Finally, designating one of these stable steady states as y^L and another as y^H, suppose that relative to the poverty threshold y^{POV}

$$y^L < y^{POV} < y^H. \tag{3}$$

In this case, there exist levels of poverty and nonpoverty that are fully self-perpetuating. Eq. (3) thus constitutes one formalization of the idea of a poverty trap: moving from specific income values to ranges of incomes, families whose incomes lie in the vicinity of y^L will remain poor forever while families whose incomes lie far enough away from y^L will not. This situation captures the qualitative poverty trap ideas i and ii.

Under what conditions can (3) arise for dynamics (1)? Algebraically, the existence of a poverty trap requires that there exist income levels $y_1 < y_2$, such that $\varphi(y_2) - \varphi(y_1) > y_2 - y_1$. If $\varphi(\cdot)$ is everywhere differentiable this condition requires that $\varphi'(\cdot) > 1$ for some values of $y_{i,t}$; it can also hold if there is jump discontinuity in $\varphi(\cdot)$. What do these algebraic conditions mean? When translated into language on the effect of parental income on offspring income, the conditions mean that in order for this form of a poverty trap to occur, it is necessary that families with higher incomes can, for some income ranges, experience more rapid income growth than families with lower incomes. In other worlds, there must be income ranges where an additional

dollar of parental income leads to more than an additional dollar of offspring income. And what applies across families must also apply within families, i.e. it must be the case that for a given family, income growth is increasing with respect to initial income for some income levels. Notice that there is no requirement that income growth is increasing in income at all income levels. Hence, over a cross-section, one can observe an average tendency for income growth to be negatively correlated with initial incomes even though a poverty trap is present.

Eq. (1) is a reduced form description of equilibrium behavior and so is a black box in that it describes the equilibrium dynamics of income for a family but does not explicitly describe the mechanisms by which income of a parent affects an offspring. In other words, the function $\varphi(\cdot)$ is determined in equilibrium by the underlying decision problems of parents. As noted above, one mechanism that provides an income process consistent with eq. (1) involves human capital formation and is the one studied by Becker and Tomes (1979) and Loury (1981). The economic logic underlying these models is straightforward: parents divide income between consumption and human capital investment in children; these human capital investments, in turn determine income when children become adults[7]. If the level of investment in children is a nondecreasing function of income and the marginal product of human capital investment on adult income is strictly positive, family income will evolve according to eq. (1) with $\varphi(\cdot)$ nondecreasing in y. Delineating this type of structure is important as it indicates that one must be careful in talking about causes of poverty traps. As the human capital explanation shows, there is an interplay between the preferences of parents (which determines the relationship between income and human capital investment) and technology (which determines the transformation of human capital into income). These will interact to determine whether or not the conditions for a poverty trap can hold. It is important to be clear that this sort of explanation in no way "blames the poor." When preferences are homogeneous, the investment decisions of the poor are identical to those the more affluent would make in the same position.

While eq. (1) is consistent with the Becker and Tomes and Loury frameworks, poverty traps do not arise in either of their analyses. The reason for this is that each of these analyses placed assumptions on the mapping from human capital to income that in essence, ensured that

[7]This formulation is similar to economic growth models in which aggregate economies build up capital stock via savings and consumption decisions.

$\varphi'(\cdot) < 1$ everywhere. Alternative specifications can produce different properties for $\varphi(\cdot)$ and hence generate poverty traps while preserving the behavioral foundations of their models. One way a poverty trap can occur is if the production function exhibits a region of increasing returns to human capital formation. A second way to produce a poverty trap in the family dynasty context is via lumpiness in human capital investment. If transitions across human capital levels require fixed costs to be paid, then $\varphi(\cdot)$ can exhibit a jump as the poor do not make these investments whereas the nonpoor do; Azariadis and Drazen (1990) is a classic example of a poverty trap driven by jumps.

The example of fixed human capital investment costs raises an important issue in the economics of poverty traps, namely the question of whether they require some sort of market incompleteness to sustain them. One reason concerns the ability of adults to borrow. Depending on the returns to human capital investment, poor families might wish to borrow in order to invest in their children and break a poverty trap. One impediment to borrowing of this type was first recognized by Loury (1981): parents cannot borrow against the future earnings of their children. Other types of financial market imperfections have been studied, see for example Galor and Zeira (1993). This type of explanation implies that there can be efficient redistribution of educational resources in the sense that equalization leads to greater aggregate output.

This first conceptualization of a poverty trap may be fragile in an important sense. Suppose that one allows for randomness in incomes via a variable $\varepsilon_{i,t}$ which summarizes labor market luck, shocks to ability of offspring compared to parents, etc.,[8] and modifies the income process from eq. (1) to

$$y_{i,t} = \varphi\left(y_{i,t-1}, \varepsilon_{i,t}\right). \tag{4}$$

Questions about poverty dynamics, traps, etc. of course immediately become probabilistic in such a context. For example, long run differences between families are more naturally described by calculations of objects such as the expected gap between two families in the future given the gap in their contemporary incomes, i.e.

[8]For ease of exposition, I do not introduce separate notation for shocks experienced in youth and in adulthood as the additional generality provided is not exploited in my discussion.

$$\lim_{T\to\infty} E\left(y_{i,t+T} - y_{j,t+T} \left| y_{i,t} - y_{j,t}\right.\right). \quad (5)$$

If this expected value is 0, one has a condition that is analogous to (2) above as it says that the expected value of any future gap will shrink to 0 given the current gap between the incomes of two families. Similarly, one can calculate the probability that a poor family will stay poor for the arbitrarily distant future, i.e.

$$\lim_{T\to\infty} \Pr\left(y_{i,t+T} < y^{POV}, y_{i,t+T-1} < y^{POV}, ..., y_{i,t+1} < y^{POV} \left| y_{i,t} < y^{POV}\right.\right). \quad (6)$$

If the probability described by (6) equals 1, then one has the equivalent of eq. (3) for a random environment; once one is poor, so are one's descendants. On the other hand, it is possible for (6) to lie between 0 and 1, which provides a richer notion of a poverty trap, i.e. a situation where a family is in danger of being permanently poor, although such an outcome is not guaranteed. This intermediate case recognizes the possibility of a Bill Gates being born into a poor family.

Income dynamics as generated by eq. (4) exhibit very different properties from those implied by eq. (1). By itself, this is unsurprising; the presence of the random elements $\varepsilon_{i,t}$ breaks the deterministic effect of parental income on offspring income, and hence the deterministic effect on grandchild income, etc. Transmission of current income over generations can be disrupted by values of the shocks $\varepsilon_{i,t}$. More surprising, the introduction of even a small amount of randomness can affect the existence of a poverty trap, i.e. even if (3) holds for a world without randomness, (6) can equal 0. The reason for this fragility again stems from the ability of $\varepsilon_{i,t}$ to overcome the effects of $y_{i,t-1}$ on a given individual. Particular realizations of $\varepsilon_{i,t}$ can mean that, even, if a poverty trap exists without shocks, the realizations cause a family to escape the trap. A simple algebraic example can illustrate this possibility. Suppose that income is either high or low, i.e. there are only two possible values y^L and y^H and that income dynamics obey the Markov chain

$$\Pr\left(y_{i,t} = y^L \left| y_{i,t-1} = y^L \right.\right) = \Pr\left(y_{i,t} = y^H \left| y_{i,t-1} = y^H \right.\right) = 1. \quad (7)$$

Clearly this is an example of a poverty trap in the sense of (3). On the other hand, suppose that income is stochastic and follows

$$\Pr\left(y_{i,t} = y^L \left| y_{i,t-1} = y^L \right.\right) = \Pr\left(y_{i,t} = y^H \left| y_{i,t-1} = y^H \right.\right) = 1 - \delta. \quad (8)$$

No matter how small δ is, one can show that each family dynasty will spend, on average, one half of the time in poverty; further, any rank order in incomes between dynasties at one point in time will reverse itself with probability 1. Hence, no family is trapped in poverty and it is additionally guaranteed that any income differential between two families at one point in time will be reversed in the future. The message of this example is that the introduction of randomness can fundamentally change the predictions of deterministic models, depending on how the randomness interacts with parental income in determining offspring income.

This example in which an arbitrarily small amount of randomness can eliminate a poverty trap, calls into question the utility of the concept as a literal description of some phenomenon of interest. It does not call into question, in my view, whether models of poverty traps are of intellectual interest. Rather, the import of this example is to call into question whether one should focus empirical analysis on poverty traps as defined by (6). In my judgment, the upshot of this example is that one should be concerned with developing a notion of a poverty trap that avoids the equating of a poverty trap with permanence of poverty. For the current example, a natural measure of persistence of poverty is the expected number of generations before a poor family transits out of poverty. One can show, for eqs. (7) and (8) that the expected number of generations for a poor family to transition to nonpoverty is $\frac{1}{\delta}$. As δ approaches 0, $\frac{1}{\delta}$ diverges to infinity so this measure replicates the notion of permanent poverty when there is no stochastic element. Expected passage times, in my view, are the more natural object of interest for empirical studies; put differently, a poverty trap as defined by (6) is a limiting and in certain ways idealized case of persistent poverty. In contrast, a poverty trap defined as a condition in which there exist long expected passage times out of poverty. Doing so better respects

heterogeneity in the effects of poverty on individuals, since $\varepsilon_{i,t}$ is nothing more than unobserved individual-specific heterogeneity.

What does this mean operationally? Letting $M^{P,NP}\left(y_{i,t}\right)$ denote the expected value of the first passage time out of poverty for a family with initial conditions $y_{i.t} < y^{POV}$, one can define families in a poverty trap as those for which

$$M^{P,NP}\left(y_{i,t}\right) \geq K. \tag{9}$$

The expected passage time before escaping poverty is, in my view, a natural statistic of interest if the objective of the analyst is to understand persistence, i.e. feature i of poverty traps. Of course, K needs to be specified by the analyst, but that is not a defect of the measure but rather acknowledges that it is a judgment as to how much persistence should be designated a trap; the first definition made such a judgment by setting $K = \infty$. The function $M^{P,NP}\left(y_{i,t}\right)$ itself can be calculated from the data. It is worth noting that calculations of this type are relatively standard in mobility analyses which focus on Markov transition processes.

A third way to think about poverty traps, one that also permits a smooth transition between nonstochastic and stochastic environments, is to employ the structure of eq. (4) to uncover how initial conditions affect long run income levels. Assuming that the shocks $\varepsilon_{i,t}$ are uncorrelated across time (correlation in the shocks is straightforward, although not necessarily trivial to handle as one simply works with the unpredictable components of $\varepsilon_{i,t}$ instead of $\varepsilon_{i,t}$ itself) one can construct a new time series

$$\tilde{y}_{i,t+T} = \varphi\left(\tilde{y}_{i,t+T-1}, 0\right) \text{ given } \tilde{y}_{i,t} = y_{i,t}. \tag{10}$$

The variable $\tilde{y}_{i,t+T}$ represents the family income levels that would occur under the counterfactual that all shocks starting at time t equal 0. It is not a variable that one observes; it is the counterfactual sequence of family incomes that would have been observed if shocks to adult income were to cease. The properties of this time series reveal the extent to which current

income inequality is or is not self-correcting as it studies income dynamics after unpredictable future events are purged; as before, this process will, under the assumption that $\varphi(\cdot,0)$ is non decreasing in $\tilde{y}_{i,t+T-1}$, either diverge to infinity or possess a well defined limit

$$\tilde{y}_i^{\lim}\left(y_{i,t}\right) = \lim_{T\to\infty} \tilde{y}_{i,t+T} \text{ given } \tilde{y}_{i,t} = y_{i,t}. \tag{11}$$

This limit is expressed as a function of income at time t. The limit may or may not be independent of the value of $y_{i,t}$. Durlauf (1995) first introduced this counterfactual and argues that if the limit in eq. (11) depends on $y_{i,t}$ so that long run behavior depends on initial conditions (in this case income), this property captures what economic historians have meant by path dependence. With respect to poverty traps, one can modify (3) to define a poverty trap as the existence of income levels such that

$$\tilde{y}_i^{\lim}\left(y^L\right) < y^{POV} < \tilde{y}_i^{\lim}\left(y^H\right). \tag{12}$$

This concept corresponds to idea ii, that poverty traps involve the absence of self-correcting mechanisms to overcome current poverty, but relaxes the requirement that poverty is permanent. The objective in moving to this definition of a poverty trap is to distinguish between cases where poverty fails to be persistent because of shocks versus the case where poverty fails to be persistent because of the socioeconomic structure which determines the effect of parental income on their children. This concept of a poverty trap has yet to be investigated.

Turning from concepts of poverty traps to their formulations, (1) and (4) are both limited in that they treat family income as a sufficient statistic for the intergenerational transmission of economic status. For any vector of socioeconomic characteristics $x_{i,t}$, one can consider a more general intergenerational model described by

$$y_{i,t} = \varphi\left(y_{i,t-1}, x_{i,t}, \varepsilon_{i,t}\right) \tag{13}$$

and

$$x_{i,t} = \xi\left(x_{i,t-1}, y_{i,t-1}, \xi_{i,t}\right). \tag{14}$$

As a mathematrical idea, eqs. (13) and (14) are a trivial generalization of (4) in that the system describes the joint evolution of $\left(y_{i,t}, x_{i,t}\right)$ and so relaxes the assumption that parental income is the only channel by which parents affect offspring[9]. One traditional candidate for an element of $x_{i,t}$ is some genetic factor that is equated with cognitive ability. Without commenting on the importance of this factor (Goldberger (1977) stands the test of time as a critique of efforts to attribute persistent inequality to genetic differences), my concern is instead with new research pioneered by James Heckman,[10] research that has demonstrated the importance of personality traits such as patience and self control in determining socioeconomic outcomes. A key finding in Heckman's work is that adult personality traits are heavily influenced by early childhood experiences. For the purposes of understanding poverty traps, intergenerational persistence in personality traits, for example, can produce intergenerational persistence in poverty. The transmission of socioeconomically undesirable personality traits from parent to offspring will, I believe, represents an important determinant of the intergenerational transmission of poverty and will come to be seen as increasing as central to the problem of persistent inequality; Heckman (2008) provides an overview of the effects of personality traits on socioeconomic outcomes as well as evidence of the role of families in the creation of these traits.

[9]The term $\xi_{i,t}$ is introduced in order to allow for unobserved heterogeneity in the determination of $x_{i,t}$. As such, it is simply the analog to $\varepsilon_{i,t}$.

[10]See Cunha and Heckman (2007) for a theoretical model of skill development that captures the major stylized facts of human development and Cunha, Heckman and Schennach (2010) for empirical implementation of the model. Borghans, Duckworth, Heckman and ter Weel (2008) provides an overview of research from the social and natural sciences on human development. Heckman, Moon, Pinto, Savelyev and Yavitz (2010) demonstrates how intensive interventions in early childhood can generate benefits in adulthood for disadvantaged children; Heckman, Malofeeva, Pinto and Savelyev (2010) shows that these benefits involve personality traits as opposed to IQ.

Location-Based Models

The family- or individual-specific perspective on income dynamics renders the location of the trap irrelevant. In other words, there is nothing about the community or region which matters for the trap; if the members of the population were redistributed across different communities or regions, their prospects would be unaffected, assuming that eq. (1) is a complete description. The only sense in which a region is a poverty trap is that it is comprised of families who, because of family influences are consigned to poverty.

A second class of income dynamics, one in which location matters, may be trivially generated by including vectors of location-specific factors $c_{l,t-1}$ and $c_{l,t}$ in the income dynamics process. Focusing on equation (4), such models can be written as

$$y_{i,t} = \varphi\left(y_{i,t-1}, c_{l,t-1}, c_{l,t}, \varepsilon_{i,t}\right). \tag{15}$$

The vectors $c_{l,t-1}$ and $c_{l,t}$ capture location influences that occur during childhood versus adulthood. So, one set of location-specific factors may affect the development of ambition during childhood, while a different set of location-specific factors may affect job prospects as an adult.

It is evident that the presence of these location effects can generate persistent poverty. So long as there is sufficient heterogeneity in $c_{l,t-1}$ and $c_{l,t}$ and sufficient sensitivity of φ to these vectors, then it is obvious family dynasties placed in different locations can exhibit permanent income gaps in the sense of (5) and that one family can be stuck in poverty in the sense of (6) while another is not. In this respect, eq. (15) is able to simultaneously capture poverty trap concepts i, ii and iii. In order for this to happen, the location specific differences will themselves have to exhibit a sufficient level of persistence. Once this is so, then the persistence of the location-specific factors creates a wedge in the incomes of families that inhabit different locations[11].

[11]Notice that family specific factors could in principle produce poverty traps, a possibility I ignored above. There has not been much interest in permanent family differences given what is

Some elements of $c_{l,t}$ may be exogenous, canonical examples include geography and weather. Other locational factors may not literally be exogenous, but may evolve sufficiently slowly so that they may be treated as exogenous over time horizons over which poverty dynamics are evaluated. Examples of this type include cultural norms or political institutions. For purposes of analyzing income dynamics, the key feature of $c_{l,t}$ is that its behavior may be taken as given without rendering the analysis incomplete. Manski (1993) refers to such factors as contextual effects, borrowing terminology from sociology.

A different way to introduce locational effects involves introducing feedbacks from the behaviors of members of the location to the behaviors of each individual. These feedbacks can occur over time or occur contemporaneously. Focusing first on intertemporal feedbacks, let $y_{-i,l,t-1}$ denote the vector of income levels for families in location l other than i at time $t-1$; introduction of this additional factor generalizes the income process to

$$y_{i,t} = \varphi\left(y_{i,t-1}, y_{-i,l,t-1}, c_{l,t}, c_{l,t-1}, \varepsilon_{i,t}\right). \tag{16}$$

It is common to assume that the average income of others $\overline{y}_{-i,l,t-1}$ is a sufficient statistic for the effects of others on a given adult's income, so that (16) can be simplified to

$$y_{i,t} = \varphi\left(y_{i,t-1}, \overline{y}_{-i,l,t-1}, c_{l,t}, c_{l,t-1}, \varepsilon_{i,t}\right). \tag{17}$$

Formulation (17) is the basis of an important class of formal models of poverty traps; Loury (1977) is a remarkable early version of this model. In terms of underlying economics, the dependence of adult income on the incomes of the families in the location in which one grows up can occur because of the local finance of public schools; see Bénabou (1996a,b) and Durlauf

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known about regression to the mean in IQ. Further, efforts to identify permanent differences in IQ in ethnic groups have been a failure, due to identification problems most effectively demonstrated by Arthur Goldberger. Goldberger (1977) is still the classic study in this regard. I conjecture that the recent work by James Heckman on personality traits can provide basis for family specific poverty traps induced by persistent interfamily heterogeneity.

(1996a) for examples of formal analyses of neighborhoods and the transmission of poverty based on this public finance mechanism.

A second source of the intergenerational dependence in (17) may involve role model effects. If adolescents make schooling choices such as effort on the basis of future economic benefits, the assessment of these benefits may depend on the distributions of educational levels and incomes observed in a community. Stratification of communities according to income will correspondingly mean that different locations produce different inferences about the value of education. See Streufert (2000) for a complete analysis of this type of locational effect. Recent research on the economics of identity (Akerlof and Kranton (2000,2002) provides a third explanation for (17). Suppose that one effect of educational choices by an individual concerns how he relates his own identity to that of others in his community. If the link between education and identity depends on the characteristics of parents, then it is possible that (17) is an approximation to the effects of identity on choice. To be concrete, in a community where few parents are well educated, high education can render an individual feeling alienated from those with whom he wants to share an identity. This argument has been of long standing importance in understanding racial inequality as a number of authors have argued that black educational attainment is hampered by the perception that academic success is a form of "acting white" (Fryer and Torelli (2005), Ogbu (2003)). Suggestive evidence also exists of low aspirations among Appalachian youth, e.g. Ali and Saunders (2008). In general, the personality traits emphasized in Heckman's research can plausibly be regarded as determined at a community as well as a family level; one obvious example is the internalization during childhood of shame associated with a self-control failure. This seems a promising direction for future work on group-determined poverty traps, of which location models of the type I have described are a subset. Note that while I focus on income as the determining variable, work on personality traits suggests the need to model the social effects for a richer set of socioeconomic variables.

A final modification of the income dynamics equation to include contemporaneous locational influences is no deeper than adding these influences to (16). Assuming that average income of others is a sufficient statistic, this leads to

$$y_{i,t} = \varphi\left(y_{i,t-1}, \overline{y}_{-i,l,t-1}, \overline{y}_{-i,l,t}, c_{l,t-1}, c_{l,t}, \varepsilon_{i,t}\right). \tag{18}$$

When choices are discrete, this model thus corresponds to social interactions models of the type studied by Brock and Durlauf (2001a,2006,2007) and other authors; see Durlauf and Ioannides (2010) for a recent survey. One source for contemporaneous income interdependences is informational: to the extent that labor market information flows across social networks, economic success by a member of one's network can mean greater information. Empirical evidence of this phenomenon is developed by Topa (2001) and Bayer, Ross and Topa (2008); the first paper also provides a formal theoretical model of information transmission. Other explanations may involve forms of increasing returns to scale of the type that are pioneered by Lucas (1988) and Romer (1986) for human and physical capital respectively. If returns to scale occur with respect to human or physical capital, this again suggests the need to move beyond locational income as the mechanism for location-based poverty traps. Manski (1993) denoted the contemporaneous interdependence of socioeconomic outcomes as endogenous social effects to distinguish them from social effects that are generated by, from the perspective of time t, predetermined variables. Note that $\overline{y}_{-i,l,t-1}$ is a contextual effect.

From a theoretical perspective, the introduction of $\overline{y}_{-i,l,t}$ is especially interesting as its presence means that the model has the capacity to produce multiple equilibria for the cross sectional density of incomes within a given location at a fixed time. In terms of thinking about poverty traps this is of particular importance as it creates the possibility that two locations with identical distributions of individual and locational characteristics can exhibit different levels of aggregate income. How can this happen? Suppose one considers work effort rather than income as the object of interest. If the productivity of effort is complementary in the effort of others, i.e. the marginal product of increased effort by one worker is increasing in the effort levels of others, then the effort choices of each individual will be increasing in the effort levels of others[12]. If this complementarity is strong enough, then there will exist multiple effort levels across a population;

[12]Formally, for a function $f(r,s,...)$, r and s are complementary if $\frac{\partial^2 f(r,s,...)}{\partial r \partial s} > 0$. In words, the marginal effect of increasing one variable is itself an increasing function of the level of the other. One can extend this definition to vectors and generalize to cases where functions are not twice-differentiable; see Milgrom and Roberts (1990) and Vives (1990) which introduce general definitions and launched the study of equilibria of environments with complementarities.

each of these distributions of effort levels is self-consistent in the sense that they represent Nash equilibria: no one has an incentive to change his effort level given the choices of others. This example illustrates a general principle; when complementarities in individual income levels are strong enough, then multiple equilibria in the total income distribution can result.

When can multiple steady states occur? Brock and Durlauf (2001a,2006) show, for discrete choices, that the number of equilibria in a given economic context depends on the interplay of private and group characteristics with the strength of complementarities. Intuitively, if private incentives polarize the population toward one type of behavior, then complementarities cannot create sufficient bunching so that the population on average tips to the other choice. Further, if the distribution of individual-level unobservables generates large draws with sufficient frequency, then the percentage of the population left over to react to other factors will be insufficient to generate multiple distributions of self-consistent bunching. This formalizes the idea that sufficient iconoclasts in a population can break socially-enforced conformity among others. As was the case for the individualistic models of poverty traps, the robustness of a poverty trap for a social model of this type depends on the ways shocks impinge on individual decisions. Unlike the family-specific income dynamics model (1), however, what matters in the locational model is whether enough aggregate heterogeneity is induced by the introduction of shocks to overcome the potential of strong conformity effects tipping the rest of the population towards one behavior or another because of the social interaction effects.

Growth

The discussion up to this point has focused on environments in which incomes do not systematically grow. The modern economic growth literature has focused on cases where interactions can lead to perpetual and endogenous growth. The basic idea, initially proposed in seminal work by Lucas (1988) and Romer (1986), is that the productivity of capital investments, whether human or physical, depends on the investments of others in the economy. Applying these ideas to the Appalachian case, one would say that the effect of human capital on one worker's productivity is increased by greater human capital on the part of others. Lucas and Romer sought to explain long run divergence between developed and lesser developed economies and so focused on the case where these spillovers produced "social increasing returns

to scale" which means that if the capital levels of others is fixed, a given individual faces a decreasing returns to scale mapping of capital into income, while aggregate economy exhibits increasing returns. For our purposes, their model is a variant of (18) in which the individual income variables grow without bound.

In terms of the conceptions of poverty traps I have described, perpetual growth requires a modification of the various formalizations. One possibility is to think of traps in terms of relative versus absolute deprivation. This would involve considering the behavior of variables such as $\log\left(y_{i,t} / y_{j,t}\right)$; the use of logs accounts for the idea that in growing economies, a fixed difference in income becomes a negligible fraction of the incomes. A relative deprivation trap could then be conceptualized as one in which contemporaneous inequality can be permanent, with positive probability i.e.

$$\lim_{T\to\infty} \Pr\left(\log\left(\frac{y_{i,t+T}}{y_{j,t+T}}\right) \geq K, \log\left(\frac{y_{i,t+T-1}}{y_{j,t+T-1}}\right) \geq K, \ldots, \log\left(\frac{y_{i,t+1}}{y_{j,t+1}}\right) \geq K \,|\, \log\left(\frac{y_{i,t}}{y_{j,t}}\right) \geq K \right) > 0 \quad (19)$$

To render this notion of a poverty trap operational, the value of the threshold level K needs to be set just as it had to be set in our earlier definitions of poverty traps in absence of growth.

One question is whether the sorts of generative mechanism that produce social increasing returns to scale in aggregate economies apply to regional economies. Romer and Lucas put much emphasis on idea generation. Lucas (2009) argues

> What is it about modern capitalist economies that allows them, in contrast to all earlier societies, to generate sustained growth in productivity and living standards?...What is central, I believe, is the fact that the industrial revolution involved the emergence (or rapid expansion) of a *class* of educated people, thousands, now many millions-of people who spend entire careers exchanging ideas, solving work-related problems, generating new knowledge. (p. 1)

One can see analogies to regional development in this statement. Bollinger, Ziliak, and Trotske (2009) find evidence that returns to education are lower in Appalachia than the rest of the United States, which is consistent with Romer-Lucas type spillovers, although this fact would arise wherever education levels of workers are complementary in production functions.

A Summary Statistical Model

In using any of these dynamic income models to assess data, our discussion indicates the importance of including both individual and location-specific factors. Further, it is necessary to allow for individual and locational specific unobservables. With respect to locations, it seems especially important to distinguish between unobserved location-specific heterogeneity experienced in youth as opposed to adulthood. One reason for this belief is that the social factors that are germane to development across childhood, e.g. the formation of norms, seem very distinct from those that matter at adulthood, e.g. unobserved features of labor market demand. If we define the location specific unobservables as $\eta_{l,t}$, one can combine the various models I have described into a general process for individual income:

$$y_{i,t} = \varphi\left(y_{i,t-1}, x_{i,t-1}, x_{i,t}, \overline{y}_{-i,t-1}, \overline{y}_{-i,t}, c_{l,t}, c_{l,t-1}, \varepsilon_{i,t}, \eta_{l,t-1}, \eta_{l,t}\right). \tag{20}$$

This specification respects the distinctions between individual and locational influences, observable and unobservable heterogeneity, and contextual and endogenous factors. As such, it naturally corresponds to the type of statistical model one would apply to individual income dynamics.

There is an important dimension, with respect to which this formulation is incomplete: it says nothing about why individuals live in particular locations. In the case of country-wide poverty traps, this is not an important lacuna given international immigration restrictions, but in the case of the United States, the determination of residential location needs to be modeled in order to have a complete theory. In the poverty trap literature, the standard explanation as to why poorer families do not move to locations that will maximize human capital in their offspring is that housing prices and rents sustain substantial socioeconomic segregation. When one considers racial inequality, discrimination may act as a separate barrier; see Yinger (1995) for evidence on housing discrimination and Heckman (1998) for a critique of this work.

Before turning to econometric issues, it is worth observing that location-specific factors raise question of interventions to affect the allocation of individuals across localities. In Durlauf (1996b) I have termed this associational redistribution. Many locational factors act as

externalities in the sense that they are not directly adjudicated by markets; peer group effects are a standard example. This is so even if prices (i.e. house prices or rents) for locations support the allocation of agents; see Becker and Murphy (2000) for a very clear treatment and Bénabou (1996a) for detailed analysis. Hence, it would seem that there can be efficient interventions in market allocations of individuals across locations. On the other hand, the presence of complementarities between characteristics of agents can render stratification by these characteristics efficient; this is Becker's classic (1973) result on the efficiency of assortative matching, i.e. stratification of groupings. One can identify cases where complementarity does not render assortative matching efficient (Prat (2002), Durlauf and Seshadri (2003)); Bénabou (1996b) is a standard reference for studying the efficiency of stratification in the context of school districts when complementarities occur at both local and aggregate levels. Nevertheless, Becker's basic message delimits the probable efficiency gains from government interventions in group formation that are designed to equalize agent characteristics across groups. Location-driven poverty traps may therefore represent an example in which one may have to trade off equality against efficiency.

Identification

In this section, I discuss the question of identifying poverty traps. The objective of the discussion is to both illustrate the identification problems that arise in producing elements of poverty traps as well as to describe strategies for overcoming these problems. To make the general econometric issues concrete, I consider a specific empirical proposition and its interpretation.

Suppose one argues that Appalachia's historically high poverty rates as compared to the rest of the country represent prima facie evidence of a poverty trap. It is straightforward to argue that this empirical regularity, in fact does not necessarily constitute evidence of a poverty trap with respect to *any* of the conceptions of a poverty trap with which I started Section 2. Idea i, persistence in individual level poverty is not demonstrated by the empirical regularity for an obvious reason: persistence in individual poverty does not logically restrict aggregate poverty levels in a location. This follows immediately from the fact that the percentage of a population

in poverty does not identify anything about the dynamics of individual poverty processes[13]. Further, one can think of a plethora of reasons why high aggregate poverty rates in a region would be uninteresting from a policy perspective. One reason is migration; persistent poverty in a location can reflect location decisions of agents who would be poor regardless of location; by analogy, the concentration of poor in low quality housing does not imply that low quality housing is a poverty trap; but may simply reflect self-selection of the poor into the housing. Idea ii, absence of self-correction of poverty cannot be deduced from high aggregate poverty for exactly the same reasons. Idea iii, the presence of aggregate reasons for individual poverty, does not follow from persistent poverty either. Here the reason is simple: nothing in the aggregate poverty rate's persistence speaks to its causes. One cannot tell from high aggregate poverty whether it is due to low family specific investments in human capital because of individual family poverty, a weak tax base for public education, absence of incentives to invest due to the state of the coal industry, particular social norms about education or other factors. Taking poverty trap ideas seriously requires much more detailed knowledge about individual income dynamics.

Evaluating Poverty Traps via Time Series Properties

One strategy for generating evidence of poverty traps may be derived from explicit consideration of the time series properties of individual income dynamics. Calculations of this type directly address the phenomena of persistence and absence of self-correction in poverty. As suggested above, it is important to allow for nonlinearities in the transition function. Despite their commonality in theoretical work there has been relatively little empirical work on the question of nonlinearities in the intergenerational transmission mechanism. For the United States, exceptions include Cooper, Durlauf and Johnson (1994), who find little correlation between parental and offspring income outside the tails of the income distribution. A particularly careful analysis for non-US data is Antman and McKenzie (2007) which estimates nonlinear

[13]The mathematical point is that poverty in a region is a description of the cross-section density of incomes at a point in time, which does not map one for one back to a particular dynamic process for the incomes.

intergenerational models for 15 years of individual data on urban Mexican workers and finds little evidence of nonlinearity.

In translating the statistical notions of poverty traps into restrictions on the time time series processes for income, it is important to recognize a limitation in using differential income growth rates between the rich and poor to infer the presence of poverty traps: namely, while poverty traps require the possibility that the rich grow faster than the poor, the observation that the poor in fact grow faster than the rich does not imply the absence of a poverty trap. The reason can be seen in the nonstochastic version of the individual-based poverty trap model described by eqs. (1) and (3): in the vicinity of each of the steady states described in eq. (3), one has the property of local convergence, i.e. those below the steady state grow towards it while those above it shrink. Bernard and Durlauf (1996) discuss this problem. One implication of their analysis is that linear models of income dynamics cannot be used to assess poverty persistence; specifically it is possible to find a cross-sectional correlation between initial income and income growth in an environment with poverty traps because this correlation does not account for any nonlinearities associated with the poverty trap.

A second identification problem concerns nonlinearity versus poverty traps. Following Durlauf, Johnson, and Temple (2005), the difficulty arises in the relationship between clustering of behaviors around a discrete number of values and the presence or absence of multiple steady states. Clustering implies that there are few observations that are not associated with the clusters and hence uncovering transition dynamics towards clusters is difficult. In the context of our model, the problem can occur because of a lack of information about behaviors around the discontinuities in (1); for the continuous case the problem would arise if the set of incomes over which $\varphi'(\cdot) > 1$ is small.

A third problem arises with respect to the accuracy of estimates if one treats the definition of a poverty trap as requiring permanent poverty. Such a stark requirement is difficult to assess from data which are observable over a relatively small epoch, say 50 years. In the time series literature, this problem has arisen in the context of the study of unit roots in macroeconomic data. A unit root in a time series requires that some part of the contemporary change in a time series permanently affects the level of a time series, so there is a close relationship to the poverty trap claim that a change can leave someone in or out of a trap. For

income y_t, the expected long run implication of a contemporaneous change in income may be calculated via

$$\lim_{T\to\infty} E\left(y_{t+T}\left|\Delta y_t\right.\right) = \sum_{j=-\infty}^{\infty} \operatorname{cov}\left(\Delta y_t, \Delta y_{t-j}\right) \tag{21}$$

Hence calculating permanent effects involves high order covariances, which are extremely difficult to estimate accurately without extremely long samples, an issue first assessed in Cochrane (1988). Thus, if one formalized the notion of a poverty trap as requiring that some transformation of aggregate poverty rates exhibits a unit root, evidentiary support will be problematic. The same holds for other conceptions of poverty traps; the semiparametric analyses such as Cooper, Johnson, and Durlauf and Antman and McKenzie avoid this problem by focusing on transitions across a single generation which rules out any higher order temporal dynamics. In my view, this problem reinforces the importance of focusing on probabilities of passage out of poverty for different time horizons.

Locational Mechanisms

A different strategy for uncovering poverty traps is to focus not on time series regularities, but on the identification of feedbacks from various locational characteristics that correspond to contextual and endogenous social interaction influences on individual outcomes. From this viewpoint, the objects of interest are the derivatives of eq. (21) with respect to the social interactions variables. If one can uncover these derivatives, one can infer poverty trap outcomes in the sense of iii. This is the strategy that is employed in the social interactions literature. The most common social interactions models are linear regression variants of (21); if one were to map (21) into a linear regression it would take the form

$$y_{i,t} = \kappa + \alpha_1 x_{i,t-1} + \alpha_2 x_{i,t} + \beta_1 c_{l,t-1} + \beta_2 c_{l,t} + \gamma_1 \overline{y}_{-i,l,t-1} + \gamma_2 \overline{y}_{-i,l,t} + \eta_{l,t-1} + \eta_{l,t} + \varepsilon_{i,t}. \tag{22}$$

The most important variant of this model is one in which choices are discrete variables. For simplicity, I focus on the binary choice case; denote these outcomes $y_{i,t} \in \{0,1\}$. Of course, in this case, $y_{i,t}$ is presumably not income but rather an outcome such as high school completion, use of a regional dialect, etc. In this approach, the net utility to choice 1 by agent i at t, $u_{i,t}$, obeys an analog to (23)

$$u_{i,t} = \kappa + \alpha_1 x_{i,t-1} + \alpha_2 x_{i,t} + \beta_1 c_{l,t-1} + \beta_2 c_{l,t} + \gamma_1 \overline{y}_{-i,l,t-1} + \gamma_2 \overline{y}_{-i,l,t} + \eta_{l,t-1} + \eta_{l,t} + \varepsilon_{i,t} \qquad (23)$$

so that the observed behavior follows

$$y_{i,t} = 1 \text{ if } u_{i,t} > 0;\ y_{i,t} = 0 \text{ otherwise}. \qquad (24)$$

My specifications of both the linear regression and binary choice models are more complicated than the statistical models that have usually been employed to study social interactions and by implication the models that one would naturally turn to study regional poverty traps. This is because of the attention to distinct determinants of outcomes at different stages of life and because of the explicit attention to unobservables.

Before discussing identification of these models, it is important to observe that the specifications assume that the elements of x and c are known. This can be problematic since theoretical models of individual and location determinants typically fail to specify how determinants should be measured. For role models, is the correct variable the percentage of white collar jobs among adults or the percentage of college graduates among adults? This sort of question can be repeatedly applied to the statistical models that are conventionally employed. Further, my specifications follow the literature in taking locations that define social interactions as known. As argued in Akerlof (1997), it is natural to think about agents arrayed in a possibly high dimensional social space; this may or may not correspond well to counties and neighborhoods, which define the locations over which measurement is conventionally done. Finally, my specifications, again following the social interactions literature, assume that each agent places the same weight on the characteristics and behaviors of every other agent. Once one relaxes this assumption, one moves from models of social interactions to models of social

networks[14] and the identification issues facing an analyst become very different. Blume, Brock, Durlauf, and Ioannides (2010) and Blume, Brock, Durlauf and Jayakrishnan (2011) show how some of the standard identification problems vanish once one moves away from conventional social interactions specifications and further show that identification can be achieved under particular forms of partial knowledge of social network structure.

Within the contexts of models of the form of (22) and (23), the econometrics literature has focused on three distinct identification problems that arise when attempting to uncover locational influences when using statistical models of the type I have described. Blume, Brock. Durlauf and Ioannides (2010) provide formalizations of the problems as well as an exhaustive description of the literature; a gentler introduction is Durlauf and Ioannides (2010). Here, I simply wish to describe the problems a researcher faces.

The first identification problem facing studies of social influences was initially studied in Manski (1993) and is known as the reflection problem. The reflection problem refers to difficulties in disentangling the role of contextual effects $c_{l,t-1}$ and $c_{l,t}$ from the endogenous effects $\overline{y}_{-i,l,t-1}$ and $\overline{y}_{-i,l,t}$. This difficulty arises because the contextual effects help to determine equilibrium values of the endogenous effects. Manski provides a demonstration that for cross-section linear models, the reflection problem may render it impossible to identify different locational effect parameters. Brock and Durlauf (2001a) show that the reflection problem does not arise in discrete choice models in the sense that because these models are nonlinear, collinearity between contextual and endogenous effects may be ruled out, so long as there is sufficient variability in the contextual effects across locations. Brock and Durlauf (2001b) and Blume, Brock, Durlauf and Ioannides (2010) show that the reflection problem can also be overcome in dynamic contexts because dynamics can affect the degree of linear dependence between the contextual and endogenous effects. Nevertheless, even if identification does not fail per se, the reflection problem indicates that parameter estimates may be highly imprecise.

A second econometric problem derives from self-selection into locations. Following the broader microeconometrics literature, self-selection of locations is typically addressed in two ways. First, instrumental variables may be employed. An early and well known application of

[14]See Jackson (2008) for a clear and exhaustive description of the modern social networks literature.

this strategy is Evans, Oates and Schwab (1992) who studied social interactions in schools. In order to address self-selection in schools, Evans Oates and Schwab used school district level instruments, arguing that self-selection is limited to schools within districts, and not the districts per se. This example reveals some of the difficulties in using instrumental variables. Even if the Evans, Oates and Schwab argument on self-selection is correct, this is not sufficient to ensure instrument validity. The problem is that $\varepsilon_{i,t}$ contains all factors that are not accounted for by the locational and individual-specific controls. In order for a district-level instrument to be valid, one must be able to argue that it is not correlated with any of these factors. As a mathematical statement, the presence of $\eta_{l,t}$ is sufficient to make this impossible, except for nongeneric cases. Substantively, the problem is what Brock and Durlauf (2001c) have called theory-opendendness: models such as eqs. (23) and (24) are not derived from full specifications of individual decision problems and therefore do not rule out determinants outside of those that are included. For the Evans, Oates and Schwab context, it is not unreasonable to conjecture that an instrument such as district level dropout rates is correlated with per pupil expenditure or broader social norms that affect decisions.

An alterantive strategy is to explicitly model the self-selection process. In turn, there are two ways to proceed. The standard approach is due to Heckman (1979) and involves introducing a regressor which measures the conditional expectation of the model error modulo a constant of proportionality; this is in fact now known as the control function approach. While implementation of the control function is most often done using parametric assumptions on the probability density of unobserved heterogeneity, there are semiparametric ways to construct selection corrections. An alternative strategy involves coupling the outcome equations with models of the location selection process; Epple and Sieg (1999) is a nice example. This strategy requires complete knowledge of the location selection process.

Either version of the second strategy is, in my view, preferable to the use of instrumental variables. In particular, explicit analysis of self-selection can assist in the identification of social interactions. Brock and Durlauf (2001b) first demonstrated that it was possible for the reflection problem to preclude identification when individuals are randomly assigned to locations while if locations were chosen, identification was possible; Brock and Durlauf (2006) and Ioannides and Zabel (2008) extend this approach theoretically with Ioannides and Zabel applying it

successfully to demonstrate the presence of social interactions in housing valuation. Why would self-selection facilitate identification? Selection of locations constitutes an additional choice on the part of individuals, and so contains information on the determinants of these choices, determinants that presumably include the social interactions that will be experienced conditional on residing in the location. This information can help to triangulate the presence of social interactions to the extent that the interactions influence his locational choices.

A third identification problem derives from the presence of unobserved location-level heterogeneity, i.e. the presence of $\eta_{l,t-1}$ and $\eta_{l,t}$ in (23) and (24). In my judgment, the identification of social interactions effects in the presence of unobserved group effects represents the major existing impediment to developing evidence of the role of social influences. First, it is generally the case that for those contexts in which social interactions are usually studied, there are many unobserved group characteristics that can be plausibly argued to affect individual outcomes. For Appalachia, factors ranging from the quality of legal and political institutions to geography plausibly matter in explaining poverty, but are difficult to measure. Second, unlike the case of self-selection, unobserved group factors do not themselves typically derive from a behavioral model the way that location selection does. Hence, there is nothing analogous to the control function approach that may be employed to address their presence. Most efforts to address unobserved group effects have therefore involved instrumental variables methods or, when the effects are time invariant, differencing of data to exploit temporal variation.

For the reasons I have outlined, there continues to be considerable disagreement about the empirical importance of social interactions. Recent econometric work has focused on uncovering robust evidence. By robust evidence, I mean evidence of social interactions that explicitly accounts for the presence of various types of unobserved individual and locational heterogeneity.

One approach to developing robust evidence is due to Brock and Durlauf (2007) for binary outcomes and in essence does the following. Suppose that one observes that there exist two locations, l and l' and a vector z which is a sufficient statistic for the effects of individual and contextual characteristics on the aggregate locational outcome. What I mean by this is that the only factors that determine the average choice levels outside of z are unobserved group effects and endogenous social interactions. Suppose that one observes

$$\bar{y}_{l,t} > \bar{y}_{l',t} \text{ and } z_{l,t} < z_{l',t}. \quad (25)$$

Brock and Durlauf call this a pattern reversal: the basic idea is that the observable fundamentals suggest one rank ordering of locational outcomes whereas the observed pattern of outcomes reverses this ordering. Under the behavioral model I have described, a pattern reversal can occur because 1) the group effects $\eta_{l,t}$ reverse the rank order in outcomes generated by $z_{l,t}$ or because 2) there are multiple equilibria in aggregate outcomes, so that l has coordinated on a high outcome equilibrium whereas l' has coordinated on a low outcome equilibrium. When can the first explanation be ruled out? Brock and Durlauf provide a set of shape restrictions on $\eta_{l,t}$ such that the data would lead one to conclude that social interactions are present. For example, if higher z locations draw from a more favorable η distribution, then an observation consistent with eq. (26) allows one to conclude that endogenous social interactions are present in the data and that they are strong enough to produce multiple equilibria. As such, this is a form of a partial identification argument. The appeal of the pattern reversal approach is that it focuses on the one feature of endogenous social interactions that other factors simply cannot produce: multiple equilibria.

The Brock and Durlauf (2007) strategy does not apply to linear models for the trivial reason that such models cannot produce multiple equilibria. Some progress has been made on identification in linear models with group level unobservables in Blume, Brock, Durlauf, and Jayakrishnan (2011). The key here is to consider which parameters can be identified under different types of unobserved heterogeneiety. While Blume, Brock, Durlauf, and Jayakrishnan focus on cross section models, their analysis suggests that for panel data, location-level unobservables may permit identification of some parameters of policy interest, though to be clear this is a conjecture.

A second strategy is due to Graham's (2008) extension and generalization of work by Glaeser, Sacerdote, and Scheinkman (1996) on the impact of endogenous social interactions on the variance of average outcomes across locations. In this approach, one considers the relationship between the variance of $\bar{y}_{l,t}$ and the population size of l. If there are no endogenous social interactions, then this relationship will be different than when endogenous social interactions are present. Intuitively, endogenous social interactions introduce

dependencies across individual choices that "slow down" the rate at which the law of large numbers applies. Glaeser, Sacerdote and Scheinkman's analysis does not allow for group effects; Graham's achievement is to show that if these effects are random rather than fixed, and if the variance is independent of group size, one can uncover evidence of endogenous effects by contrasting variances across group sizes. The random effects assumption implicitly requires that location choices are unaffected by the shocks.

A third strategy is proposed in Brock and Durlauf (2009) and involves studying transitional dynamics. Their framework considers adoption of a technology, for an educational context one can think of the development of skills to use a new technology, for example computers. Brock and Durlauf ask what sorts of restrictions are imposed on adoption over time, when the benefits to a technology reflect social interactions. For their model, they show that social interactions can introduce jumps in adoption rates in the economy as well as pattern reversals between adoption rates of those whose private characteristics would suggest they should adopt earlier versus others. To be concrete, suppose that one observed that computer technology diffused more slowly in a high education location versus another but that there are jumps in the adoption rates of each community considered in isolation. Brock and Durlauf in essence provide sufficient conditions under which one can conclude social interactions are present.

To be clear, none of these strategies is a panacea. Each requires substantive behavioral assumptions. We began by emphasizing one critical assumption: the uniformity of social interactions between individuals, so that the average characteristics and behaviors of others are a sufficient statistic for characterizing social influence. Other assumptions are implicit in the way that unobserved heterogeneity is modeled. Hence these identification strategies can only be assessed in a specific empirical context.

Data

My discussion of identification has focused on statistical tools as opposed to data collection. One major question concerns the measurement of social groups within a broader social space. The discussion of identification has presupposed only that the groups which define social interactions are known a priori. I conjecture that language use may facilitate measurement

of social groups. It is well understood that dialects are important sources of identity, cf. Wolfram and Schilling-Estes (2006). Nonstandard dialects in Appalachia have been a major topic in the sociolinguistics literature; Wolfram and Christian (1976) is an especially detailed study. Not only could dialect data, in principle, help with the measurement of social networks, it could help to understand the mechanisms by which networks affect socioeconomic outcomes. Luhman (1990) is an interesting study that considers how standard dialect speakers in Kentucky form stereotypes about nonstandard dialect speakers in Kentucky as well as the extent to which these stereotypes are also believed by the nonstandard speakers. I would even speculate that the internalization of stereotypes can, in turn, affect noncognitive traits.

Further, as demonstrated in Blume, Brock, Durlauf and Ioannides (2010), many identification problems disappear when social networks are known a priori; formally, for known social networks[15] in linear models, the set of linear models under which identification fails can be shown to be nongeneric. Hence data collection that allows the construction of social networks is of first order value. The current frontier in understanding identification of social effects lies in the study of cases where there is partial knowledge of social networks.

Footprints of Poverty Traps

In this section I focus on some stylized facts about Appalachia that would seem to hint at poverty traps. While this discussion is admittedly speculative, it reflects impressions I have gleaned from studies of Appalachia as to ways to uncover social interactions that are strong enough to produce poverty traps under the various conceptions that have been described.

Education

The stylized facts on Appalachian educational attainment are suggestive, in my view of a poverty trap. Isserman (1996) is one example of a literature that documents how Appalachia

[15]By known social network, I mean not only who affect who, but also the strength of these effects up to a constant of proportionality. In essence, this generalizes the linear in means model by allowing for unequal weights across others in a population.

appears to be an outlier in terms of the high percentage of counties in which less than ½ the 1990 adult population graduate from high school. Bollinger, Ziliak and Troske (2009) similarly attribute much of the failure of Appalachian wages to converge to those in the rest of the country to lower human capital formation; this paper is noteworthy for its careful and sophisticated econometrics. Low human capital investment in Appalachia is a good candidate for a mechanism underlying a poverty trap. As discussed earlier, the sort of behavioral explanation that one can make is that educational investment decisions are interdependent because of both role model and peer influences, so that factors such as parental education and the educational choices of peers affect each individual's decisions. Evidence of social interactions in education has been developed in many studies. Crane (1991) is an early example in which interneighborhood variations in high school graduation are associated with the occupational characteristics of parents. Recent examples include Cooley (2008) and Hanushek, Kain, Markman and Rivkin, (2003) who focus on peer effects at the school and classroom level. For these reasons, I regard the fact of sustained disparities in education to be a hint of a poverty trap. Nevertheless, by itself, the social interactions/poverty trap interpretation falls prey to the sorts of identification problems I have described.

To proceed, consider two other stylized facts. The first is identified in Isserman: for socioeconomic indicators other than education, it is much more difficult to identify Appalachia as an outlier relative to the rest of the country. The finding that high school completion behaves differently from other socioeconomic indicators is potentially of great importance in uncovering why it occurs. A second stylized fact is due to Shaw, deYoung, and Rademacher (2004) who find that the bulk of the Appalachian educational gap is due to central Appalachia. This is most starkly seen in terms of high school graduation: in 2000 76.8% of Appalachian adults had high school degrees as opposed to 80.4% for the US as a whole. In contrast, only 64.1% of central Appalachian adults are high school graduates. The high dispersion of education outcomes in Appalachia across subregions provides the sort of variability that helps uncover social interactions.

In what sense might these additional facts help one make an empirical case for an Appalachian poverty trap? With respect to Isserman, the anomalous behavior of education versus other socioeconomic indicators makes an explanation based on unobserved location factors less plausible. The reason is simple: the unobserved factor will need to be one that only

affects education, since it evidently does not affect other factors. While this may apply to teacher quality, it does seem plausible from the perspective of social norms. As for Shaw, deYoung, and Rademacher (2004), if it is the case that, assessing county by county, one finds that the low educational attainment associated with central Appalachia violates patterns of education as would be predicted by variables I have described by $z_{l,t}$ above, this would constitute a pattern reversal. Interpretation of these reversals as social interactions would require taking a stance on unobserved group heterogeneity. If the relevant factor is teacher quality, it is plausible to assume that teacher quality is drawn from a distribution that is no better for high outcome counties than others. Alternatively, one might wish to assume unimodality of the unobservables and see if one finds conditional multimodality in outcomes. The Graham approach can also be used if one can argue that the unobservables are uncorrelated with z. Lichter and Campbell (2005) document sufficient heterogeneity in poverty reductions in the 1990's to suggest this route may be informative.

Migration

Second, I conjecture that substantial information on social interactions can be gleaned from understanding the determinants of migration in and out of Appalachia. Whether or not Appalachia is a poverty trap, socioeconomic conditions would lead one to expect substantial migration away from the region. Actual migration patterns are in fact much more complicated. Obermiller and Howe (2004) document that in the latter 1990's Appalachia experienced substantial inflows and outflows of population. Underlying these flows are important differences between in and out migration. Obermiller and Howe find that central Appalachia experienced nontrivial outflows of more skilled adults that were largely counterbalanced by inflows of less skilled ones; more generally Baumann and Reagan (2005) argue that slightly over 1/8 of the gap in college graduates between Appalachia and the rest of the United States can be attributed to migration.

There appear to be puzzles in the migration patterns that warrant study in terms of what they say about social interactions. One puzzle, at least to me, is that the out migration of the high skilled has not been more rapid, especially in light of findings such as Bollinger, Ziliak and Troske (2009) that returns to human capital are nontrivially lower in Appalachia than elsewhere.

Nor is it clear why low skilled workers would choose Appalachia as a destination. The retention of high skilled workers suggests the presence of social interactions effects that make Appalachia more appealing than its observed socioeconomic characteristics would suggest. On the other hand, the in migration of low skilled workers suggests that self-selection issues exist with respect to the Appalachian population that mitigate against simple claims of the region being a poverty trap per se; a public housing project is not a poverty trap by virtue of the fact that poor people live there. My point is that analysis of migration decisions can augment social interactions analyses based on various outcomes of Appalachian residents. Comparisons with migration patterns for other disadvantaged regions may also be informative.

Given the sensitivity of Appalachian economic conditions to the price of coal, the time series properties of these prices may prove a fruitful source for understanding social factors in Appalachia. The utility of coal price shocks in understanding employment and earnings changes was first recognized in Black, Daniel, and Sanders (2002). My conjecture is that the reactions of migration to persistent changes in the price of coal can be informative about social factors that affect migration just as shocks to coal prices are informative about short run changes in labor market outcomes.

Conclusion

In these notes, I have tried to do three things. First, I have described some formal intergeneration income models that can produce behaviors which capture various facets of the idea of poverty traps. Second, I have discussed some of the statistical challenges facing any effort to establish the presence of a poverty trap in a given data set. Third, I have used Appalachian educational attainment and migration as examples of where one might wish to begin a systematic search for evidence of poverty traps in light of some established aggregate regularities.

I end these notes with a few comments on policy. First, efforts to ameliorate Applachian poverty need to respect the level of policymaker ignorance. Theoretical models of poverty traps and formal econometric analyses of the identification of mechanisms that can produce poverty traps are largely divorced from the current body of formal empirical work on poverty. This gap

between theory, econometrics and empirics means that the current literature provides relatively little quantitative guidance on policy construction. This policymaker ignorance should not lead to a Hayekian avoidance of policy interventions. Rather, policymakers should focus on identifying policies that are robust in the sense that their efficacy holds across different specifications of the income determination process for individuals and for communities. Further, given the paucity of formal research on Appalachian poverty, the existing body of qualitative work can play an especially useful role in both policy design and in evaluating the utility of poverty trap ideas[16].

Second, antipoverty policies should reflect the interplay of locational as well as individual level explanations of poverty. In terms of direct, targeted interventions, new literature on early childhood development is an obvious source for antipoverty policy recommendations. Social interactions imply that the effects of widespread application of early childhood interventions of the intensity of the Perry Preschool Program (which has been the focus of much of Heckman's research) may, via social multipliers, be even more cost effective than has already been found for specific programs. On the other hand, to the extent that these early childhood interventions need to be intensive in order to be efficacious, budget considerations may require that they are concentrated across a subgroup of locations where poverty is high. This raises complicated equity/efficiency tradeoffs as discussed in Durlauf (2006). At the other end of the spectrum, the sorts of place-based policies discussed in Kahn (2010) may require that early childhood experiences are such that the potential for a skilled workforce is already latent in the population, in the sense that sufficient levels of noncognitive skills are present in the population to allow these policies to be effective. One example, Kahn's suggestion that improvement of transportation infrastructure is a promising place-based strategy for Appalachia. While I certainly endorse Kahn's recommendation, workers with low noncognitive skills are unlikely to benefit much from connections between Appalachia and other areas. Synergies between individual and group level policies give reasons for optimism in reversing persistent poverty even for cases as longstanding as is found in Appalachia, although this optimism, as suggested in my first comment, should be tempered by the limits of our understanding of the specifics of Appalachian policy.

[16]See Duncan (1999) for an exemplary study which contrasts Appalachia with New England crafts communities and Mississippi Delta sharecropping communities.

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Theories of Poverty Traps and Anti-Poverty Policies. Maitreesh Ghatak London School of Economics. December, 2014.Â We focus on poverty traps at the level of the individual: two individuals who are identical in all respects but only diÂ¤er in their initial wealth may end up with diÂ¤erent steady state incomes, and do not look at aggregate level poverty traps, which could operate at the economy-wide level.2. 1See Banerjee and Mullainathan (2008). 2See Azariadis (1996) and Banerjee (2003) for reviews of the literature on poverty traps, including those at the aggregate level. Also, we do not look at general equilibrium eÂ¤ects. See Mookherjee and Ray (2003) for an example of a poverty trap that arises from the eq When does a poverty trap emerge? â€¢ When we compare the different curve, there is something specific about figure 1: â€¢ The S-Shaped curve intersects the 45 degree line from belowÂ â€¢ The Jeff Sachs/Angelina Jolie video pointed out to several possible poverty traps. â€“ The farmer Kennedy and his fertilizer: what could be his problem? â€“ The mother of a large family and the nutrition of her children. â€“ Other? â€¢ In each of these cases, what do we need to know to decide whether there is a poverty trap or not? â€¢ Where else could we find poverty trap? 19. The policy implications of a poverty trap. War on Poverty: Portraits From an Appalachian Battleground, 1964. Ben Cosgrove. Jan 07, 2014. The staggering range and sheer excellence of the late John Dominis' pictures â€” his Korean War coverage; his portraits of pop-culture icons like Sinatra, Redford and McQueen; his beautiful treatment of the "big cats" of Africa; his virile sports photography â€” place him firmly among the premier photojournalists of the last 75 years.Â In a lonely valley in eastern Kentucky, in the heart of the mountainous region called Appalachia, live an impoverished people whose plight has long been ignored by affluent America. Their homes are shacks without plumbing or sanitation. Their landscape is a man-made desolation of corrugated hills and hollows laced with polluted streams.