deliver consistent estimates for a range of specific problems. Some of these techniques draw on panel data when available, and many others rely on one form or another of instrumental variable estimation. In the next few subsections, I review a number of specific topics that illustrate the use of these techniques and some of the issues associated with them.

2.1.6. Agricultural production functions: heterogeneity and panel data

The estimation of farm production functions is a problem that often arises in development applications, whether we are simply attempting to relate physical outputs to physical inputs, or whether we are concerned with more elaborate models of farm-households and the associated integrated models of consumption and production [see for example Singh, Squire, and Strauss (1986)]. Production functions are one of the oldest topics in econometrics; many of the issues reviewed by Marschak and Andrews in 1943 are still relevant, and Mundlak's (1961) paper on agricultural production functions is the first — or at least one of the first — to use fixed effect estimators with panel data as a remedy for unobserved heterogeneity. The simultaneity and omitted heterogeneity problems in this case arise in many other related applications.

A good starting point is the "obvious" procedure, which is to regress outputs on inputs, as for example in

$$In(q_i/A,) = \text{---}\ 13_0 + \text{fi}_t \ln A, + 131\text{n} + (3_3 \text{ In } z - F u; \tag{29}$$

where A, is land, so that $€7,1A,$ is the yield per hectare of farm *i, 12,* is labor input, and z, is some other input, such as fertilizer, or perhaps the farmer's education. The sign of Q_i is relevant to the question of whether large or small farms are more "productive", the coefficient $/3_2$ tells us about the marginal productivity of labor on family farms, and the size of /3, might tell us whether inputs are being efficiently used, since a very large marginal product of fertilizer relative to its costs might be used as an argument for intervention in distribution or extension services.

The problem is that OLS estimation of (29) will tell us none of these things. The finding that A, > 0, that smaller farms have higher yields, is the traditional one since Chayanov's (1925) findings for Russian farmers, and has been widely observed elsewhere [see for example Sen (1962) for India, and Berry and Cline (1979)] for a review of other research. There are many interpretations of the result; that higher output per head is an optimal response to uncertainty by small farmers [Srinivasan (1972)], that there are dualistic labor markets, [Sen (1966, 1975)], or that hired labor requires more monitoring than family labor, [Feder (1985)]. Perhaps the simplest explanation is that (29) omits unobserved heterogeneity, in this case land quality, and that this omitted variable is