4.5 Lurking third variables

(a) *Bombing accuracy and presence of fighter planes.* During the Second World War the US Air Force had developed a regression analysis of bombing accuracy, into which many variables were dumped. In essence this was a classic Fishing Expedition as described in §4.1. Tukey considered the significance and implications of these variables.

In the analysis, one puzzling positive correlation he examined was between the numbers of enemy fighter planes present and the accuracy of the bombing. How could bombing be more accurate when enemy fighters were harrying the bombers? Of course it was not like this at all. The third variable was *cloud*. Cloud, and the fighters couldn't find the bombers; they didn't scramble. Cloud and the bombers had trouble finding their targets. Clear and it was vastly easier to find the bombing targets, even with the unwelcome fighter planes present.

(b) *Stock market indices and sunspot cycle.* The correlation is well-known, but mainly as folklore. The term 'sunspot' is even associated with market-prediction agencies. Trying to substantiate any such correlation is very difficult - and trying to find an underlying physical cause even more so. It may exist; global temperature is now known to correlate with sunspot number and long-term weather trends may have physical, social and economic effects.

There are clear trends (or characteristic intervals at least) in stock-market indices on time-scales of several years and the dot-com bubble is the most recent of these. The solar cycle (sunspot activity) is 11 years in length and it is not a clean sinusoid. Inevitably over some periods of time there will be marked correlations, even in the absence of any physical correlation or cause-and-effect.

(c) *Apparent angular size of radio source and radio luminosity.* Are intrinsically more powerful radio sources smaller? No - they are statistically further away, because the inexorable downward slope of the luminosity function to larger luminosities requires that larger volumes be sampled to find the more luminous sources. Greater distances implies that same-sized objects subtend smaller angles.