VARIABLE LOCATION AND SCALE KERNEL DENSITY ESTIMATION

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Abstract. Variable (bandwidth) kernel density estimation (Abramson (1982, *Ann. Statist.*, **10**, 1217–1223)) and a kernel estimator with varying locations (Samiuddin and El-Sayyad (1990, *Biometrika*, **77**, 865–874)) are complementary ideas which essentially both afford bias of order h^4 as the overall smoothing parameter $h \to 0$, sufficient differentiability of the density permitting. These ideas are put in a more general framework in this paper. This enables us to describe a variety of ways in which scale and location variation may be extended and/or combined to good theoretical effect. This particularly includes extending the basic ideas to provide new kernel estimators with bias of order h^6. Technical difficulties associated with potentially overly large variations are fully accounted for in our theory.

Key words and phrases: Bias reduction, smoothing, variable bandwidth.