Particle-size effects on the critical thickness on the ferroelectric properties of nanoscale BaTiO$_3$ particles are investigated using a first-principles molecular orbital method and population analysis for the next change and overlap population. A series of models composed of a Ba$_3$Ti$_7$O$_6$ cluster and point charges surrounding the cluster are employed for calculations of the electronic structures of the BaTiO$_3$ particles, with the size of the model defined by the size of the point charge array. Results of the calculations show that the critical thickness for the ferroelectric-to-paraelectric transition for nanoscale BaTiO$_3$ particles decreases as the area of the base of the rectangular particles decreases.