We present a systematic study on the bulk and surface electronic structure of hexagonal PtBi$_2$. Through careful comparison with first-principle calculations, our experiment distinguishes the low-lying bulk bands from entangled surface states, allowing the estimation of the real composition of samples. We find significant electron doping in PtBi$_2$, implying a substantial Bi-deficiency induced disorder therein. Intriguingly, we discover a Dirac-cone-like surface state on the boundary of the Brillouin zone, which is identified as an accidental Dirac band without topological protection. Our findings exclude linear band dispersion in the quantum limit as the cause of the unconventional large linear magnetoresistance but give support to the classical disorder model from the perspective of the electronic structure.