Human lung undergoes respiration-induced deformation in the form of inhalation and exhalation. Modeling the dynamics is numerically complicated by the lack of information on lung elastic behavior, structural heterogeneity and boundary constrains. This study integrates physics-based modeling and image-based data acquisition to develop the patient-specific biomechanical model and consequently establish consistent Young’s modulus of human lung. A mathematical model is developed that integrates deformation data from deformable image registration (DIR) with physics-based approaches to simulate volumetric lung dynamics. The lung is modeled as a poro-elastic medium with spatially distributed elastic property. Computation is performed on a 3D lung geometry reconstructed from 4D computed tomography (4DCT) dataset of human subjects. The heterogeneous Young’s modulus (YM) is estimated from a linear elastic deformation model with the same lung geometry and 4D lung DIR. The deformation obtained from the numerical simulation is then coupled with the displacement obtained from the 4D lung DIR by means of the Tikhonov regularization (TR) algorithm. The accuracy of the numerical solution is enhanced through fusion with the imaging data beyond the classical comparison of the two sets of data. Finally, the fused displacement results are used to establish unique and consistent patient-specific elastic property of the lung. The biomechanical model adequately predicts the spatio-temporal lung deformation, consistent with data obtained from imaging.