A systematic methodology to critically assess and screen among early stage design alternatives was developed for the use of glycerol. Through deterministic sensitivity analysis it was found that variations in the product and feedstock prices, total production cost, fixed capital investment, and discount rate, among others, have high impact on the project’s profitability analysis. Therefore, the profitability was tested under uncertainties by using NPV and MSP as economic metrics. The robust ranking of solutions is presented with respect to minimum economic risk of the project being nonprofitable (failure to achieve a positive NPV times the consequential profit loss). It was found that the best potential options for glycerol valorization is through the production of either (i) lactic acid (9 MM$ with 63% probability of failure to achieve a positive NPV); (ii) succinic acid (14 MM$ with 76%); or finally, (iii) 1,2-propanediol (16 MM$ with 68%). As a risk reduction strategy, a multiproduct biorefinery is suggested which is capable of switching between the production of lactic acid and succinic acid. This solution comes with increased capital investment; however, it leads to more robust NPV and decreased economic risk by approximately 20%, therefore creating a production plant that can continuously adapt to market forces and thus optimize profitability.