Bootstrap inference for conditional risk measures

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Chapter 7

Valorisation

"Those who ignore statistics are condemned to reinvent it."
-Bradley Efron (1938-...)

Some readers may be surprised by the fact that the term *valorization* goes back to Karl Marx and the idea of self-expansion of capital, i.e. the growth of capital through value-forming activity. On the contrary, Adam Smith, the father of modern capitalism, coined the term *human capital* to describe the workers skill set to perform labor. Merging both lines of thought, I discuss in this addendum the increase in the value of human capital (knowledge) through value-forming activity (my research). In particular, I stress the relevance of the topic *bootstrap inference for conditional risk measures* and highlight the innovativeness of this dissertation as well as the practical implementability of its methods.

To recognize the relevance of the topic, I explore the three fundamental pillars on which this dissertation is grounded: (i) conditional volatility models, (ii) bootstrap methods and (iii) risk measures. Emphasizing the importance of the first pillar, Robert Engle was awarded the Nobel Price in Economics in 2003 for his methods of analyzing time series with time-varying volatility. His ARCH model specifies the swing between turbulent and calmer periods in stock markets and its GARCH (1,1) extension is known as the workhorse of financial application. The second pillar relates to the revolutionary idea of using resampling techniques to perform statistical inference. In recognition of the bootstrap, Bradley Efron will accept the International Prize in Statistics in 2019, possibly the highest honor in this field.[1] Present-day bootstrap methods are the conventional solution in practice to construct confidence intervals that address estimation uncertainty. The third pillar of this thesis deals with the assessment of risk attributed to financial assets. Risk measures such as Value-at-Risk (VaR) and Expected Shortfall (ES) are extremely popular in Finance to quantify the exposure to risk, which is essential for making informed decisions.

The financial econometric thesis at hand is the result of pooling these fundamental insights from finance, economics and statistics. It proposes to construct bootstrap intervals for conditional VaR and ES that account for estimation uncertainty. Existing work shows that simulation results are promising, however there are no theoretical results underpinning the validity of these methods. This dissertation aims to fill this gap in the literature by providing the necessary theoretical foundations. In particular, the contribution of this dissertation to the literature is threefold. First, a fundamental issue is solved that arises in the analysis of econometric forecasting techniques. Second, refined bootstrap intervals are proposed

[1] In 2005 he was already awarded with the National Medal of Science. If there existed a Nobel Price in Statistics, Efron would have received it *almost surely*.

for conditional VaR and ES and theoretical results (based on mild assumptions) are established confirming their validity. Proving the validity of the methods is crucial as an application of invalid bootstrap methods for predicting risk can have severe impact. Third, simulations are presented supporting the theoretical results and practical recommendations are made to practitioners.

The last point immediately gives rise to the practical implementability of the bootstrap methods. Contrary to techniques based on asymptotic theory, the proposed bootstrap methods are easy-to-implement and fully data-driven as illustrated in an empirical exercise (see p. 120). In addition, the recommended fixed-design residual bootstrap technique is compatible with various conditional volatility models (e.g. GARCH, T-GARCH, etc.) and moreover faster than its recursive-design competitor. Furthermore, the significant increase in the availability of computing power makes the computational cost of the bootstrap a subordinate concern. Nevertheless, the thesis also offers variants that find a compromise in the trade-off between computational time and precision (see p. 104).

All in all, this dissertation offers valuable insights for financial institutions that are engaged in risk management such as banks, pension funds and insurance companies. Besides their intrinsic motivation to mitigate risk to an acceptable level, they are also committed by law to calculate capital requirements by means of VaR and ES and to report them to the regulatory authorities.[2] Therefore, the content of this dissertation also has a immediate appeal to regulators that are primarily concerned about excessive risk-taking. I sincerely hope that the methods presented within this thesis become part of financial practice in the future and that they find their way into the regulatory frameworks to ensure financial stability.

[2] In the banking sector the regulatory framework is called Basel III, whereas its counterpart in the insurance sector is known as Solvency II.