本文前 6 点都是来自文献“The virtues and vices of equilibrium and the future of financial economics”中的对我们有用的部分。之所以有用，是因为要理解 Sanford Grossman 关于价格的信息角色的论述，以及后续要详细总结的 Shleifer（2000）的关于无效市场的论述，都需要理解均衡概念，尤其是理性预期均衡概念（当然资产定价教科书的主体部分也需要均衡概念，但是需要的理解没那么深刻）。其实也是因为阅读 Shleifer（2000）的部分章节的时候，对一些概念比较模糊，才找文献，读到该篇。

1. 经济学的均衡概念

Market equilibrium models are designed to describe the market interactions of rational agents in an economy.市场上有 goods。Agents 可以用其 utility，endowment，和 technology 描述。The goal is to model the decisions of agents incentivized solely by their own selfish goals, and to deduce the consequences for the production, consumption, and pricing of each good.经济学的均衡概念有 4 个假设：

1.Perfect competition (price taking).Each agent is small enough to have a negligible effect on prices. Agents“take” the prices as given, in the sense that they are offered prices at which they can buy or sell as much as they want, but the agents cannot do anything to change the prices.

2. Agent optimization of utility. At the given prices each agent independently chooses what to buy, what and how to produce, and what to sell so as to maximize her utility. There is no free lunch—the cost of all purchases must be financed by sales. An agent can only buy corn, for example, by selling an equal value of her labor, or apples, or some other good from her endowment.

3. Market clearing. The aggregate demand, i.e. the total quantity that people wish to buy, must be equal to the aggregate supply, i.e. the total quantity that people wish to sell.

4. Rational expectations. Agents make rational decisions based on perfect information. They have perfect models of the world. They know the prices of every good before they decide how much to buy or sell of any good.

2. 怎样到达均衡

In 1954 Arrow, Debreu, and McKenzie simultaneously showed that there always is an equilibrium, no matter what the endowments and technologies and utilities, provided that each utility displays diminishing marginal utility of consumption and each technology displays diminishing marginal product.

但是一个经济怎么到达均衡点呢？一个思路是重复拍卖（Tatonnement，或 groping），即一个拍卖者先随便宣布一组所有产品的价格，然后每个 agent 做最优决策，得到每个 agent 在此价格下的需求量和供给量，然后看总供给是否等于总需求，如果某种商品总供给大于总需求，则下次调低该商品价格，反之调高该商品价格，这样一轮一轮拍卖下去，应该能达到均衡点。但是有证明，好些情况下这种过程，会循环下去，并不会接近均衡点。

另外一个思路是，假设每个 agent 是全知全能的，即他知道这个经济模型，即他知道每个人的效用函数，禀赋，技术，且他知道每个人都会去求个人最优解。则该 agent 就可以解出该均衡，类似地，其他 agent 也可以解出均衡，然后每隔 agent 按照该均衡解行动，就到达了均衡。博弈论的均衡的达到，也是这种思路。

3. Rational expectations

金融对于不确定性的描述使用的是tree of states of nature.如果Rational expectations概念应用在金融上，就是说 The agents are also presumed to know the tree of states of nature, and the probabilities of every branch, and to correctly forecast the prices that will emerge at each node if they get there.

The rationality hypothesis is a parsimonious description of the world that makes strong predictions. Rational expectations equilibrium models have the advantage that agent expectations are derived from a single, simple and self-consistent assumption. Without this assumption one needs to confront the hard task of determining how agents actually think, and how they think about what others think. This requires formulating a model of cognition or learning, and thereby introducing additional assumptions that are usually complicated and/or ad hoc. Without rationality one needs either to introduce a set of behavioral rules of thumb or to introduce a learning model. While perfect rationality defines a unique or nearly unique model of the world, there are an infinite number of boundedly rational models. To paraphrase Christopher Sims, once we depart from perfect rationality, there are so many possible models. It is easy to become lost in the wilderness of bounded rationality.

Perfect rationality is an impossible standard for any individual to attain, but the hope of the economist in making a rational expectations model is that in aggregate, people behave "as if" they were rational. This maybe true in some situations, and it may not be true in others. In any case, rational expectations models can provide a useful benchmark for understanding whether or not people are actually rational, which can serve as a starting point for more complicated models that take bounded rationality into account.

"At the opposite extreme from rational expectations, one can simply assume that agents have fixed beliefs, which might or might not correspond to reality [5–7]. At an in-between level one can use a so-called noise trader model in which some agents have fixed beliefs while others are perfectly rational [8, 9] (This can actually make the task of computing the equilibrium even harder, since the rational agents have to have perfect models of the noise traders as well as of each other). At a higher level one can assume that agents are not given the probabilities of states of nature a priori, but need to learn them [10,11]."

下面两段段是来自" Sources of Artificial Intelligence"的 insights。该部分强调了Rational expectations 是均衡概念，说的是均衡时候的 expectation，强调了"对经济模型共同的正确的理解"。

> *Economics is about how collections of individuals choose to utilize and to allocate sets of scarce resources. Modern economic theory is multi-person decision theory within coherent environments. The abstract artificial people inside a coherent economic model are "rational" in the sense that all of them solve constrained optimization problems that take into the account their common correct understandings of their environment. Two leading classes of such multi-person decision theories are Game theory and General equilibrium theory.*
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> *When economists speak of "rational expectations" they are referring to an assumed "common correct understanding of an environment". The phrase "rational expectations" modifies "model", not "people".*

4. 对均衡概念的扩展

前面讲的是标准的均衡概念。后来，对均衡概念有扩展。有三个方向的扩展，一是

overlapping generation，二是考虑信息不对称，三是考虑违约。

In view of all these extensions the meaning of the word “equilibrium” is not always clear. One definition would be any model that could be interpreted as satisfying hypotheses (1–4) as described in the introduction to this Section. But we also wish to allow for some boundedly rational agents. Following the practice of most economists, we will define an equilibrium model as one in which at least some agents maximize preferences and incorporate expectations in a self-consistent manner. So, for example, a noise trader model is an equilibrium model as long as some of the agents are rational, but models in which all the agents act according to fixed beliefs are not equilibrium models.

5. 效率（efficiency）

如果是完全市场（complete market），且人们都是理性的，则均衡是（在分配效率方面）Pareto optimal，如果市场是 incomplete 的，则均衡一般不是 Pareto optimal。金融市场一般是 incomplete。由于金融市场不是 Pareto optimal，金融经济学家转向其他的效率，如信息效率（informational efficiency）。信息效率是指当前价格揭示了关于未来的所有信息。这我个人理解有两层含义。一是在没有信息不对称时，（转换过的）价格过程是 martingale，可以进一步得到，条件在当期所有信息上对于下期 payoff 的预测，等于条件在当期价格上对于下期 payoff 的预测，等于当期价格。二是（见 Sanford Grossman 的相关文章），在信息不对称时，条件在当前价格和当前某个 agent 独有的信息上，对下期 payoff 的预测，等于只条件在当前价格上的预测。这第二种又称作价格具有信息加总（information aggregate）功能。

在上述第一种情况下，对于有限期的证券，其价格等于 fundamental value。Fundamental value 是未来所有期的期望分红的折现值。

除了信息有效，还有一个衡量有效的方面是套利有效。该概念是指市场无套利。

6. 策略分类

在提到对于均衡方法的替代方法时，有一类思路是研究各种策略的特点，以及策略之间的关系。A few common examples are fundamental valuation, technical trading (interpreting patterns in historical price movements), many forms of derivative pricing, statistical arbitrage, market making, index arbitrage, and term structure models. The champions of heterogeneous models believe that to understand asset pricing as it manifests itself in the real world, it is necessary to understand the behaviors of at least some of these types of agents and their inter-relationships and interactions.

该文章提出的这一点，是为了描述解释现实。即在更现实的假设下（比如不同的人采用不同的投资策略），市场会产生什么结果。但是我结合 Shleifer（2000）关于无效市场的论述，我认为这一点对于我们量化投资是很好的思路。之前，我们研究别人的策略，很大程度是看这些策略有没有效，有效的话我们也使用。现在的思路是，我们看看这些策略的思路会产生什么市场无效，，我们来看看这些我们是否能利用这些无效来构建策略赚钱。

Shleifer（2000）关于无效市场的论述（与 alphanomics 中的论述相同）。基本上是说，如果没有套利成本（比如搜集信息成本，对冲不完全风险，噪声交易风险等），即使有噪声交易者存在，由于套利者去无限套利，使得则价格等于 fundamental value。但是现实世界是有套利成本的，所以，噪声交易带来的价格不等于 fundamental value，不能被完全消除掉，所以价格即包含 fundamental value 也包含噪声部分。根据这一理论，我们可以去研究噪声交易的来源，看看是什么原因导致一些交易者首先不去理性做决策做交易。我们量化投资可以通过研究这一块，或者从文献中学习这一块（即噪声交易的

来源），来找出我们的市场中有哪些噪声交易。如果这些噪声交易没有被当前的套利者套利掉，且我们可以把它套利掉，则我们可以赚钱。第二个研究方向，是去研究套利者面临的套利成本（很可能套利成本是跟噪声交易对应的，即特定的噪声交易有特定的交易成本）。如果这些套利成本，我们有办法克服，那么我们就可以去套利赚钱。第三个研究是 fundamental value。如果我们能够获得独立且更加正确的 fundamental value，则我们可以利用价格与 fundamental value 最终很可能趋同的原理来做量化交易（价格与 fundamental value 也有可能在长时间不收敛，这就是噪声交易者给套利者带来的风险）。

7. 读经济学或金融学文献的好处

虽然经济学和金融学是解释现有的经济金融现象。比如解释价格为什么是这样。而我们量化投资的目的是要怎么通过买卖证券来赚钱。学术文献虽然不能直接告诉我们怎么赚钱，但是学术文献，尤其是顶级文献中包含了很多聪明人对金融市场的认识，比如资产价格可以认为由基本面和噪声部分构成，噪声部分是怎么来的，什么使得噪声消除不掉。这些认识是可以指导我们去寻找赚钱机会的。这些认识虽然我们如果自己在市场中去真实体验，也是有可能获得的，但是不一定能获得，而且花的时间和金钱可能不少；而我们通过文献就可以获得上述知识，花的成本更小一些。

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