Theories in Financial Economics: Part 2

Simon Naitram[1]

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[1] University of the West Indies, simon.naitram@cavehill.uwi.edu

Tonight's Lecture

- The CAPM
  - The application of the CAPM
  - Testing the CAPM
  - Three-factor models
- Bubbles
  - Rational bubbles
  - Informational frictions
  - Evidence on bubbles
  - Macroeconomics of bubbles

Section 1

The CAPM

Required Reading

- Perold, A.F., 2004. The capital asset pricing model. Journal of economic perspectives, 18(3), pp.3-24.
- Fama, E.F. and French, K.R., 2004. The capital asset pricing model: Theory and evidence. Journal of economic perspectives, 18(3), pp.25-46.

Diversification

- Diversified investors face less risk per investment than undiversified investors.
- For two assets, the portfolio variance can be written:

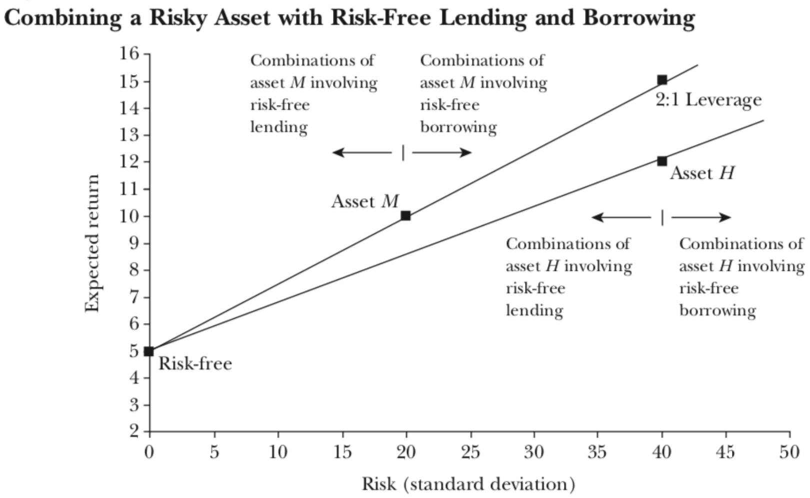
$$\sigma_P^2 = (x\sigma_A + y\sigma_B)^2 - 2xy(1-\rho)\sigma_A\sigma_B$$

  where x is the share invested in asset A and y is the share invested in asset B.
- If returns on assets are perfectly correlated, the portfolio risk is a weighted average of the risks of the assets.
- If the assets are not perfectly correlated, the risk of the portfolio is less than the average risk of the underlying assets.
- The benefit of diversification increases as ρ moves away from 1.

Diversification

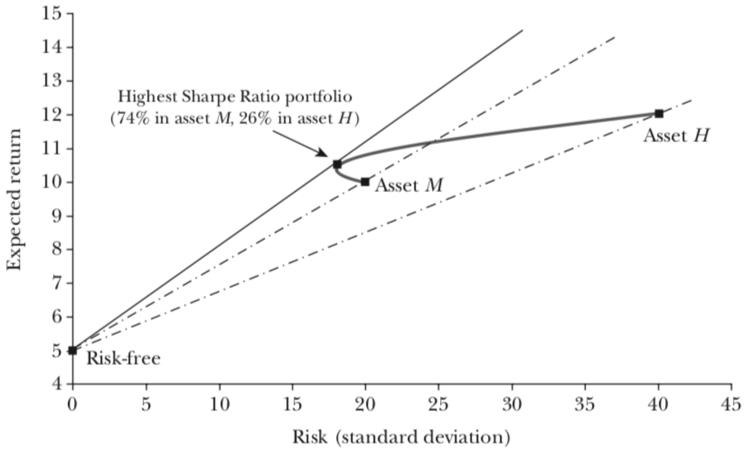
- By holding both assets in a portfolio, you can receive an expected return that is a weighted average of the two asset returns, but a portfolio standard deviation that is lower than either asset individually.
- Diversification allows you to lower risk without sacrificing return.
- The risk reduction from diversification relies on asset being imperfectly correlated, not necessarily being perfectly uncorrelated.
- The extent of risk reduction is limited by this correlation.

Choosing just one risky asset



Combining risky assets

Efficient Frontier with Two Risky Assets



CAPM equilibrium asset pricing

- In the CAPM model where everyone chooses to be on the efficient frontier: *is it possible for the expected return on an investment to be a function of its stand-alone risk?*
- Consider the shares of two firms with the same stand-alone risk and expected return (e.g. 10%)
- A portfolio combination of these two assets has an expected return of 10%.
- If the shares aren't perfectly correlated, then a portfolio invested in the shares of the two firms will be less risky than either one on its own.
- If expected return were a function solely of stand-alone risk, then the expected return on this portfolio should be strictly less than 10%.
- This contradicts the fact that the expected return is 10%.
- This means expected return cannot be solely determined by stand-alone risk.

The working CAPM

- The working version of the CAPM then is:

$$E_s = r_f + \beta(E_M - r_f)$$

or, using the definition of the Sharpe ratio $= (E_H - r_f)/\sigma_H$, we can write:

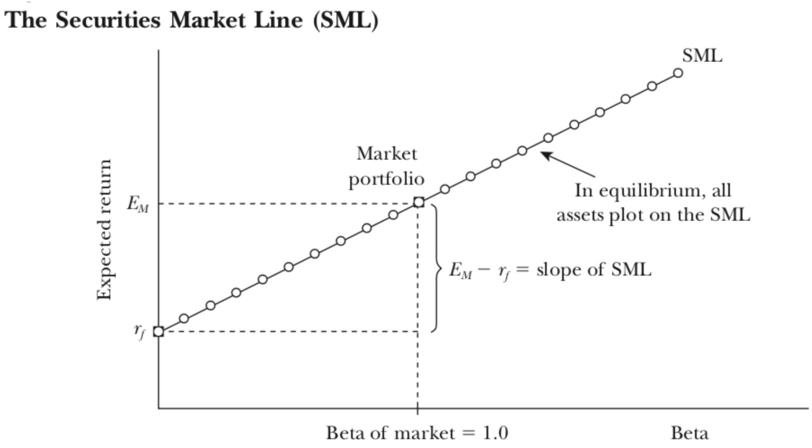
$$\text{Sharpe Ratio of Asset S} = \rho \times \text{Sharpe Ratio of the Market Portfolio.}$$

- The most striking result of the CAPM is that the expected return of the stock **does not depend on its stand-alone risk**.
- A stock with high stand-alone risk will only have a high expected return to the extent that its stand-alone risk is derived from its sensitivity to the broad market stock.

The benefit of beta

- Beta now offers a measure of the risk of the asset that cannot be diversified away.
- This implies that the average stock should have a market beta of 1.
- Now measure the risk of each asset by beta and plot it against expected return.
- If the market is in equilibrium, all assets should lie on this new securities market line.
- If not, then investors can improve on the market portfolio, obtaining a higher Sharpe ratio.
- Compare this to the original Securities Market Line.

CAPM predictions



The usefulness of CAPM

The model is elegant and intuitive. What are its uses?

- First, we can examine whether real world asset prices and investor portfolios conform to the predictions of the model.
- Second, while the model might not describe the current world very well, we can check whether it predicts future investor behaviour.
- Third, the CAPM might be able to serve as a benchmark for understanding the capital market.

The CAPM's testable predictions

- In practice, beta is estimated as:

$$\beta_{iM} = \frac{\text{cov}(R_i, R_M)}{\sigma^2(R_M)}$$

- This is the slope of the regression of the asset return on the market return, so the interpretation of beta is that it measures the sensitivity of the assets return to variation in the market return.
- The main testable predictions of the CAPM are:
  - Expected returns on all assets are linearly related to their betas.
  - The beta premium is positive.
  - Assets uncorrelated with the market have expected returns equal to the risk-free rate.
  - The beta premium is the expected market return minus the risk-free rate

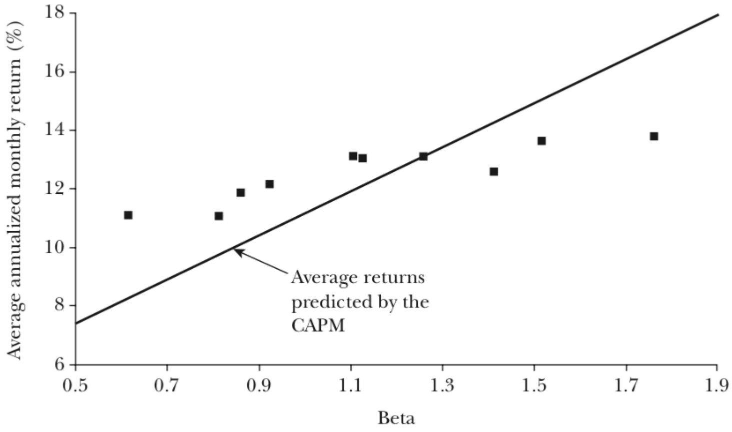
Early tests

- Authors use a cross-section of average asset returns on estimates of asset betas to test the prediction that the the intercept in the regression is the risk-free rate and the coefficient on beta is the expected excess return on the market portfolio, $E(R_M) - R_f$.
- Problems:
  - estimates of beta are already imprecise
  - regression residuals contain common sources of variation, such as industry effects
- Authors improved precision by estimating betas for diversified portfolios, although this reduces the number of betas available.
- Authors addressed correlation in residuals by using a cross section for each month of returns, rather than using average returns.
- There was also the time-series version:

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}(R_{Mt} - R_{ft}) + \varepsilon_{it}$$

Testing the predictions

Average Annualized Monthly Return versus Beta for Value Weight Portfolios Formed on Prior Beta, 1928–2003



Early tests

- Early evidence firmly rejected the CAPM.
- While there's a positive relationship between beta and the average return, it's simply too "flat".
- The intercept is greater than the average risk-free rate, and the coefficient on beta is less than the average excess market return.
- The returns on the low beta portfolios are too high, and the returns on the high beta portfolios are too low.
- At least the beta premium is positive, highlighted by the positive and approximately linear relationship between betas and average returns.

Early tests

- We can also test whether differences in expected returns across portfolios are entirely explained by differences in market betas.
- To test this, we should find that other variables add nothing to the explanation of expected return.
- In a regression, the slopes on additional variables should be zero.
- Choose additional variables to try to expose the CAPM.
- Early regression analysis found that market betas were sufficient to explain expected returns.

Where the CAPM begins to falter

- Basu (1977) found that future returns on stock with high earnings-price ratios were higher than predicted by the CAPM.
- Banz (1981) found that average returns on small stock are higher than predicted by the CAPM.
- Bhandari (1988) found that stocks with high debt-equity ratios had higher returns than predicted by the CAPM.
- Statman (1980) and Rosenberg et al (1985) found that stock with high book-to-market equity ratios have high average returns not captured by their betas.
- **Ratios involving stock prices have information about expected returns that is not captured by market betas.**

Synthesizing the evidence against the CAPM

- Fama and French (1992) pulled together this evidence, finding that size, earnings-price, debt-equity, and book-to-market ratios all add to the explanation of expected stock market returns provided by the market beta.
- If betas do not suffice to explain expected returns, the market portfolio isn't efficient—signalling the death of the CAPM.
- Acknowledging the failure of the CAPM, there are three main explanations:
  1. The data is spurious.
  2. People behave irrationally.
  3. We need more complicated asset pricing models.

The ICAPM

- Merton's (1973) intertemporal CAPM model begins with different assumptions about investor objectives:
    - They care not just about their wealth at the end of the current period, but also about the opportunities they will have to consume or invest their payoff.
    - That is, they consider how wealth at time t might vary with **state variables** such as labour income, prices of goods, investment opportunities, etc.
- In this model, optimal portfolios are now **multifactor efficient**, meaning they have the largest expected returns given their return variances *and the covariances of their returns with relevant state variables*.

The three-factor model

- Fama and French (1993) take an indirect approach to the implementation of the ICAPM.
- Rather than specifying the state variables that affect expected returns, they argue that size and book-to-market ratios reflect some unidentified state variables that produce undiversifiable risks.
- Fama and French propose their famous three-factor model of expected returns:

$$E(R_{it} - R_{ft}) = \beta_{iM}[E(R_{Mt}) - R_{ft}] + \beta_{is}E(\text{SMB}_t) + \beta_{ih}E(\text{HML}_t)$$

  - where SMB_t is the difference between the returns on diversified portfolios of small and big stocks
  - where HML_t is the difference between the returns on diversified portfolios of high and low book-to-market ratio stocks
  - the betas are the slopes in the regression that we're interested in

The three-factor model

- Fama and French (1993, 1996) find that the model captures much of the variation in average return.
- Fama and French (1998) find that an international version of the model performs better than an international CAPM in describing average returns across 13 major markets.
- The model is both widely used in empirical research and among practitioners.
- The main shortcoming is the theoretical motivation: SMB and HML aren't motivated by predictions about state variables that matter to investors.
- In practice, it's ad hoc measures are in the spirit of Arbitrage Pricing Theory.

The story of the CAPM

- The CAPM has never been an empirical success, invalidating its application.
- It may be that these problems reflect theoretical failings due to simplifying assumptions or they may reflect difficulty in actually testing the model since we barely understand what the "market portfolio" should really be.
- The Fama and French three-factor model is an improvement, but faces its own issues such as momentum and the behaviouralist critique.

Section 2

Bubbles

Required Reading

- Brunnermeier, M.K. and Oehmke, M., 2013. Bubbles, financial crises, and systemic risk. Handbook of the Economics of Finance, 2, pp.1221-1288.
- Martin, A. and Ventura, J., 2018. The macroeconomics of rational bubbles: a user's guide. Annual Review of Economics, 10, pp.505-539.

Fundamentals of bubbles

- Bubbles refer to asset prices that exceed an asset's fundamental value because current owners believe that they can resell the asset at an even higher price in the future.
- A bubbles is therefore a large, sustained mispricing of assets.
- Bubbles are of interests to economists because prices affect the real allocation of resources in the economy.
- In addition, the bursting of bubbles can have real effects by impairing the balance sheets of firms, financial institutions, and households.

Minsky's Narrative

Hyman Minsky proposed a five-phase characterisation of a bubble:

- An initial displacement, such as new technology
- The boom phase, characterised by increases in investment and credit
- Euphoria, during which the overvalued asset is traded in a frenzy
- Profit taking, during which sophisticated investors get out
- Panic phase, where investors dump the asset

Rational bubbles without frictions

- Investors are willing to hold a bubble asset because the price of the asset is expected to rise in the future.
- A bubble can be sustained today because the bubble is expected to grow in the future.
- The fundamental value of the asset is given by the difference equation:

$$p_t = E_t \left[\frac{p_{t+1} + d_{t+1}}{1 + r_{t+1}} \right]$$

  which is the discounted expected future price and dividend payment in the next period.
- If the so-called "transversality condition"—that the expected value of the price of the asset should go to zero as time goes to infinity, then price equal to fundamental value is only one of many possible solutions to the difference equation.

Rational bubbles without frictions

- Any price, given by $p_t = v_t + b_t$, where v_t is the fundamental value and b_t is a bubble component, is also a solution.

$$b_t = E_t \left[\frac{b_{t+1}}{(1+r)} \right]$$

- Any "rational bubble" then has to grow at an expected rate of r, implying that we can eliminate many potential rational bubbles.
- For example, since there are substitutes for commodities, no bubble should emerge.
- Rational bubbles should no arise if we begin with common knowledge, so that everybody knows the asset is overpriced.
- People must think there is some gain to be obtained from trading for a rational bubble to exist.

Informational frictions

- Suppose you are a rational trader and you observe a bubble. You should lean against it and eliminate it.
- However, there is a risk in doing so:
  1. Maybe you're wrong and the fundamental value might jump unexpectedly to rationalise the high price.
  2. Even if you're right, the price might still increase temporarily, causing you to lose money.
- Even rational traders then might find it optimal to temporarily ride the bubble in order to profit from it—increasing the size of the bubble, delaying its bursting, and leading to a larger market correction in the future.

Informational frictions

- It is uncertainty about the behaviour of other rational traders that makes it optimal to ride the bubble.
- A single trader cannot bring down a bubble alone—there must be a synchronized disinvestment to burst it.
- Therefore, there is a game or a coordination element among rational traders about when to burst the bubble—in addition to the need to exit the asset before others do so you can make profits!

Abreu and Brunnermeier (2003)

- Suppose the price increase is initially supported by an increase in fundamental value.
- Then beyond a specific point, the price of the asset continues to grow even though there is no further increase in fundamental value.
- From that point onwards, traders become aware that the price is too high—one after the other.
- Because they become *sequentially aware*, it is never common knowledge that there is a bubble.
- Because no single trader can burst the bubble, there is a synchronization problem: each trader tries to preempt the crash while riding the bubble as long as possible.
- This prolongs the life of the bubble, justifying riding it even longer.
- In this model, unimportant news event can trigger large price movements because they can allow traders to synchronize their selling strategies.

Delegated investment

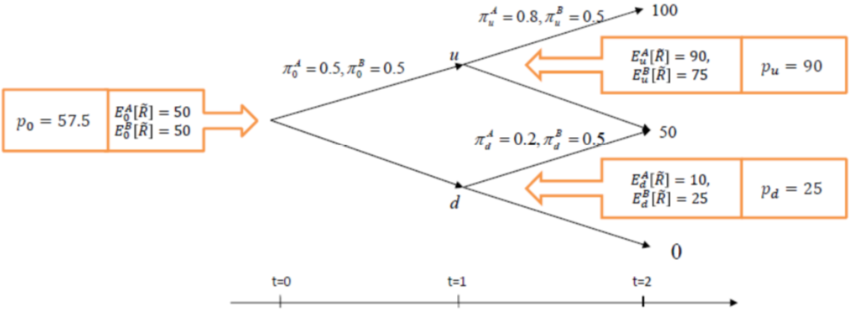
- When investors don't invest their own funds, but are instead in charge of other people's money, this can lead to further incentive distortions.
- Portfolio managers might act myopically or might buy bubble assets to pretend that they are skilled.
- Fund managers are concerned about short-run price movements because temporary losses lead to fund outflows.
- This forces managers to unwind their positions exactly when the mispricing of an asset is largest.
- The incentives to ride, rather than correct, a bubble are even larger in this setting.

Heterogeneous belief bubbles

- Investors' beliefs differ because they have different prior belief distributions, likely due to psychological biases.
- Overpricing occurs because optimists push up the asset price while pessimists cannot counterbalance it because the face short-sale constraints (either imposed by regulators or by the nature of the market).
- Prices might even exceed the valuation of the most optimist investor:
    - The most optimistic investor is holding the asset.
    - They can sell it at a high price in the future when they become less optimistic.
    - Because prices are rising, other investors are becoming more optimistic, and will be willing to buy.
    - Short-sale constraints stop pessimistic investors from pushing the price down.

Heterogeneous beliefs create bubbles

Both traders value the asset at 50 if they have to hold it until $t = 2$, but if they have the option to sell in $t = 1$, their heterogeneous beliefs about probability of the outcomes occurring leads to a bubble. Trader A thinks he can sell in the down-state, while trader B thinks he can sell in the up-state. Both investors are now willing to pay 57.5 in period $t = 0$ although they expect the asset to pay off only 50.



Empirical evidence on bubbles

- Identifying bubbles is hard, even *ex-post*, because the fundamental value of an asset is difficult to measure.
- For example, Pastor and Veronesi (2006) argue that the internet bubble of the late 1990s may be explained without appealing to a bubble logic.
- The main approach has been to test for the presence of rational bubbles, relying on the explosive feature of the bubble path.

Experimental evidence on bubbles

- The advantage of laboratory experiments is that they allow the researcher to isolate and test specific mechanisms and theoretical arguments.
- Smith, Suchanek, and Williams (1988) are the originator of a line of research where participants can trade a risky asset.
- In their work the asset pays off $d \in \{d_0 = 0, d_1, d_2, d_3\}$ with equal probability in each of 15 periods.
- The fundamental value is initially:

$$15 \sum_i \frac{1}{4} d_i$$

  declining by $\frac{1}{4} d_i$ in each period.
- They find vigorous trading, and price often rise initially despite everyone knowing that the fundamental value of the asset is declining steadily.
- They observe classic boom-bust cycles, where price often collapses toward the end of trading.

The crisis phase

- There are two distinguishing features in all bubbles:
  1. **The run-up phase**
  2. **The crisis phase**
- Crisis is the result of amplification, which result from direct and indirect spillovers.
- These spillovers work through prices, constraints, and endogenous responses of market participants. These are effectively externalities.

Macroeconomics of bubbles

- Most asset price booms are accompanied by large upswings in real activity—output, consumption, capital—and their collapses were accompanied by economic busts.
- Because most asset price boom-bust episodes end in economic recessions, macroeconomics needs to understand how large swings in asset prices affect the macroeconomy.
- These models mainly rely on the ideas that:
  - Asset prices are not driven by fundamentals alone, but also by bubbles that respond to market psychology,
  - These bubbles are consistent with individual rationality.
- That is, macroeconomics incorporates on rational bubbles into its models.

Macroeconomics of bubbles

- The key is that the price of firms does not coincide with that of their capital:

$$v_t = (1 - \delta) \cdot k_t + b_t,$$

where v_t is the market value (agg. price) of the firm, k_t is the capital of the firm, δ is the depreciation rate, and b_t is the bubble component that creates a wedge.

- Bubbles have two sources:
  - The growth of bubbles attached to old firms
  - The creation of new bubbles attached to new firms

$$b_{t+1} = g_{t+1} \cdot (b_t + n_t)$$

where n_t is the new bubbles attached to new firms and g is the growth rate of the bubbles.

Macroeconomics of bubbles

- A simplified model of market psychology suggests that new bubbles pop up only in one of two states of nature $z_t \in \{B, F\}$ that arise with some probability:

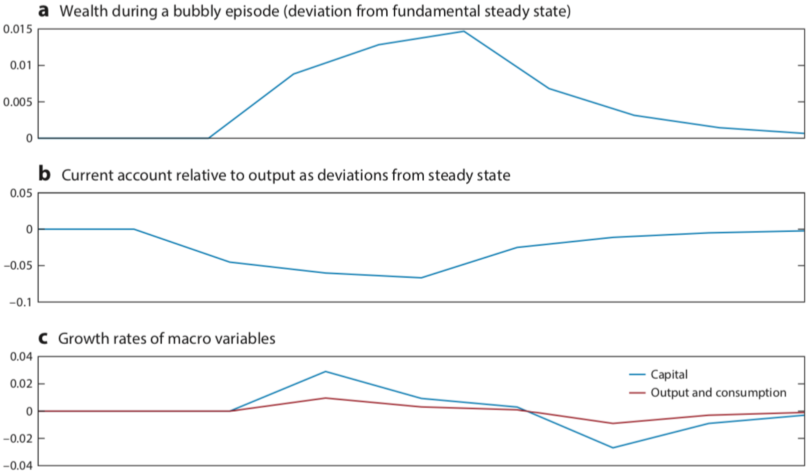
$$n_t = \begin{cases} \eta & \text{if} \quad z_t = B \\ 0 & \text{if} \quad z_t = F \end{cases}$$

- This implies that bubble creation is exogenous in these models.
- The return to holding an bubble asset its growth, which, by optimization is $E_t g_{t+1} = R$, the world interest rate.

Macroeconomics of bubbles

- The main finding is that new bubbles foster capital accumulation while old bubbles have no effect.
- A bubble shock is similar to a natural resource shock: this "revenue" constitutes a windfall or a wealth shock.
- Only when the borrowing constraint is binding does this additional wealth cause individuals to borrow some more and invest in more capital.
- From any initial condition, the capital stock converges to an *interval* $[k_F, k_B]$ and once it reaches this interval it fluctuates within here forever.
- This steady state perpetually cycles between the bubble and fundamental state.
  - In the bubbly state, asset values, borrowing and investment are all high, meaning that consumption and welfare also grow.

Bubbly episode in the lab economy



Additional reading on bubble experiments

- Dufwenberg, M., Lindqvist, T. and Moore, E., 2005. Bubbles and experience: An experiment. American economic review, 95(5), pp.1731-1737.
- Sutter, M., Huber, J. and Kirchler, M., 2012. Bubbles and information: An experiment. Management Science, 58(2), pp.384-393.
- Weitzel, U., Huber, C., Huber, J., Kirchler, M., Lindner, F. and Rose, J., 2020. Bubbles and financial professionals. The Review of Financial Studies, 33(6), pp.2659-2696.
- Galí, J., Giusti, G. and Noussair, C.N., 2020. Monetary policy and asset price bubbles: a laboratory experiment (No. 1726).
- Andrade, E.B., Odean, T. and Lin, S., 2016. Bubbling with excitement: an experiment. Review of Finance, 20(2), pp.447-466.

The End.