Dynamic Conservation Finance Strategy

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1 Question Statement

What are some good strategies of land acquisition in the face of varying land prices and budget over time?

2 Simulation

2.1 simulation of market prices and budget

There are 3 things to simulate here: market price of real estate (f_r) and forestry(f_f), and budget(f_b) of conservation agent as a function of time.

2.1.1 deterministic periodic market

First way to simulate the three state variables is through simple sinusoidal functions.

$$f_{r,f,b}(t) = A_{r,f,b}cos(\omega_{r,f,b}t - \phi_{r,f,b}) \tag{1}$$

The subscript of parameters are respective.

2.1.2 Autoregression

I also simulate real estate, forestry, and budget price by correlating each of them with a 3 degree AR model for wider economy (f).

$$f(t) = c_1 f(t-1) + c_2 f(t-2) + c_3 f(t-3) + e \quad e \sim N(0, s) \tag{2}$$

The 3 values over time are parallel to the wider economy function with its own error term that's correlated to e.

$$f_x(t) = \mathbf{cf_{L3}} + x_0 + e_x \tag{3}$$

x could either be r,f, or b subscript, and $\mathbf{f_{L3}}$ and $\mathbf{c}$ are both vector of lag term and coefficients respectively.

The correlation of $e_{r,f,b}$ to e is 0.8, 0.5, and 0.2 respectively.

correlation is between the wider economy and the 3 other compoenents are done through simulating bivariate normal varaibles between e and $e_{r,f,b}$, which is a transformation of e through the wider economy function $e_{r,f,b} = f(t)$.

2.2 Simulation of acquisition process

I assume that, much like in Lennox 2016, in every time step, a parcel becomes available for the conservation agent to buy. The agent can decide to buy and the offer only stands for one time step. SUSPECT MISSING A KEY LINKAGE HERE. FEELS LIKE MOVEMENT IN THE MARKET PRICES SHOULD AFFECT AVAILABILITY OF PROPERTIES. SO MORE TO CHOOSE AMONG AT SOME TIMES THAN OTHERS.

MIGHT STILL BE ABLE TO GET BACK TO DECIDING ON ONE PER TIME STEP FROM THE CONSERVATION ORGS PERSPECTIVE IF CRITICAL TO YOUR FORMULATION BE TRACTABLE BY ARGUING THE CONSERVATION ORG HAS LIMITED CAPACITY AND YOU THEN ARE FOCUSING ON THE ONE BEST DEAL ON OFFER IN THAT TIME STEP. BUT 'QUALITY' ON OFFER WOULD THEN COVARY WITH PRICES SOMEHOW TO REFLECT A BIGGER POOL OF PROPERTIES BEING OFFERED SOMETIMES.

cost of parcel available at time t is

$$c(t) = \sum_{i=t}^{t_j} \frac{f_f + \epsilon_{fj}}{(1+\rho)^{i-t}} + \sum_{i=t_j}^{T} \frac{f_r + \epsilon_{rj}}{(1+\rho)^{i-t}} \tag{4}$$

where t_j is a time where parcel j is converted and $\epsilon_{(f,r)j}$ is an error term for parcel j from normal distribution $N(0, \sigma)$.

BE CLEARER ON WHAT IS AN ANNUAL RETURN AND WHAT IS A PRICE. f INTRODUCED ABOVE AT LEAST AS A PRICE BUT USED HERE LIKE AN ANNUAL RETURN.

LOOKS LIKE YOU ARE ASSUMING THE SELLER KNOWS THE FUTURE TIME PATH OF PRICES. INSTEAD THIS WOULD NEED TO BE TERMS OF FUTURE EXPECTATION ABOUT PRICES. WE CAN WRITE THAT OUT AT LEAST FOR AN AR(1) PROCESS - can't remember if doing AR(3) is harder. IMPORTANTLY IT WON'T BE BASED JUST ON STATIONARY DISTRIBUTION. WITH AN AR PROCESS IF TIMBER IS CHEAP TODAY, YOUR EXPECTATION WILL BE THAT IT IS STILL CHEAP TOMORROW

MAY ALSO BE MAKING ASSUMPTIONS ABOUT OPTIMAL CLEARING TIME - NOT CLEAR IS NECESSARILY THE FIRST TIME DEVELOPMENT IS MORE VALUABLE, GIVEN CLEARING IS IRREVERSIBLE.

ALSO WORTH BEING EXPLICIT IN HERE ABOUT YOUR ASSUMPTION ABOUT HOW CONSERVATION HAPPENS. LOOKS LIKE CONSERVATION HAPPENS BY BUYING PRIVATELY OWNED FOREST PARCELS AND MAKING THEM NATURE RESERVES, CORRECT? (OTHER ASSUMPTIONS ALSO POSSIBLE, AND DIFFERENT ASSUMPTIONS ARE MORE / LESS RELEVANT TO DIFFERENT CONTEXTS).

conversion time t_j is the minimum t value where the prospective real estate

value is higher than the prospective forestry value with time discounting.

$$\sum_{i=t}^{T} \frac{f_r + \epsilon_{rj}}{(1+\rho)^{i-t}} > \sum_{i=t}^{T} \frac{f_f + \epsilon_{fj}}{(1+\rho)^{i-t}} \tag{5}$$

If the following inequality condition never meets, then t_j would be undefined and cost equation would be reduced to forestry value from time t to T.

The conservation status (s_j) of a land is a reflection of the individual error term of the parcel value ϵ_{fj}

$$s_j = \begin{cases} \epsilon_{fj} + 2\sigma, & \text{if } \epsilon_{fj} + 2\sigma > 0 \\ 0, & \text{otherwise.} \end{cases} \tag{6}$$

Conservation value that the agent receives from purchasing a parcel with conservation status s_j is the sum of status over time with time discounting starting from the expected conversion time. Different discount factor is used for the ecological value (δ).

$$v = \sum_{i=t_j}^{T} \frac{s_j}{(1+\delta)^i} \tag{7}$$

If t_j is not defined, $v = 0$.

To allow borrowing, let's say there's maximum amount of debt (d) a conservation agent can hold (max_d) and each time step one has to repay ceil(d/3). This method of debt repayment is borrowed from Lennox 2016.

2.3 buying strategies

strategies unresponsive to market situation 1) always buy if you can 2) repeat buy*i + don't buy

strategies responsive to market situation. 1) buy when conservation value v is above 0. 2) buy when v is above x. 3) buy when v is above x, but also with probability p when it's above ¿0 *4) buy when $v > x$ and $c < y$. 5) buy when conservation status s_j is above x and $0 < v < y$ (equivalent to buy when cheap and less threatened) 6) buy when s_j is above x and $v > y$ (equivalent to buy when threatened but expensive)

I think 4 will deliver the best result

2.4 questions and thoughts

-Not sure how to simulate model with certain correlation value. I feel like the autoregression step mentioned above is not correct way to correlate f to $f_{r,f,b}$. Suggestion for models that better capture the correlations among these variables will be appreciated.

- We expected that at a time when f_r ¿ f_f probability of conversion would be high but this is not necessarily true if landowners can see the long run market

price. Landowners will only sell if staying in forestry is not as profitable as developed land considering all time till T. Therefore, even if f_f is lower than f_r at present,if the landowner sees that the values will flip and stay flipped in the long run, they won't develop the land. Therefore, if the discount rate is low, where future profits matter a lot, the concept of threatened expensive and un-threatened cheap (TEUC) may not exist.

- Even if discounting was very high such that only present value matters, TEUC may not hold. How threatened a land is is only dependent on the difference between f_f and f_r, whereas the land cost is the cost of whichever land cost is more expensive at the time (not thinking of value in the future). Therefore, it's possible that land cost is expensive and not threatened, and also cheap and be threatened.

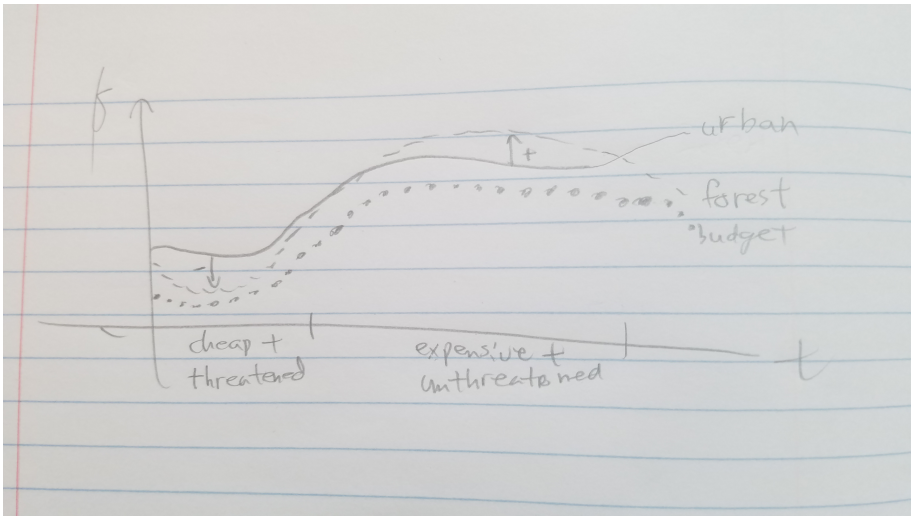

Figure 1: Fig1. Example case of land being threatened and cheap (left side), and un-threatened and expensive (right side).

- because we can only simulate finite timeline, nearer time parcel is going to be more expensive then the later time parcel given everything else the same. To minimize this effect, if we were to simulate buying process until T, we would have to simulate the market process until T' where $T < T'$ and $\delta, \rho \mapsto T'$

IF WE CAN GET IT FORMULATED CAN PROBABLY TAKE AN INFINITE LIMIT IN THE EXPECTED PRICE.