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.

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 $N(0, \sigma)$.

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 $v > 0$ and $c > y$ 4) buy when conservation status s_j is above x and $0 < v < y$ (equivalent to buy when cheap and less threatened) 5) buy when s_j is above x and $v > y$ (equivalent to buy when threatened but expensive)

I would say 4 would be the best strategy because

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 $f_{r,f,b}$. - 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.

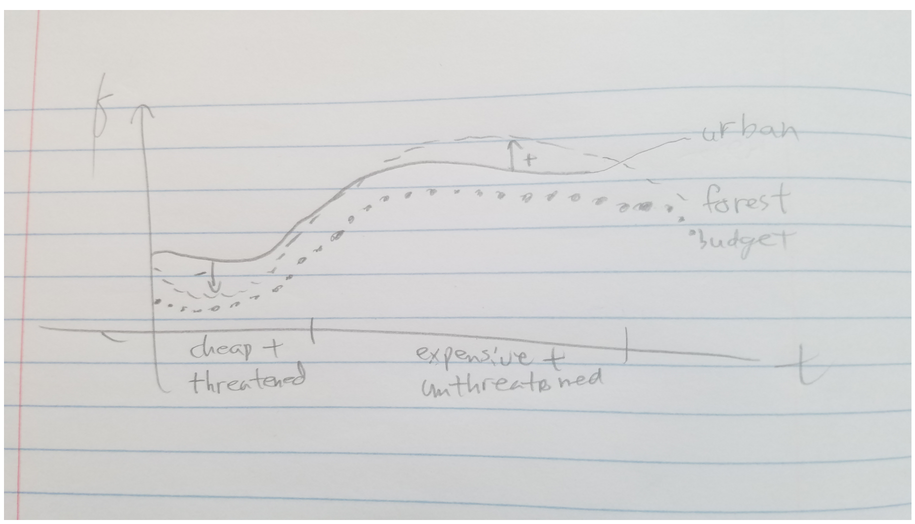

Figure 1: Fig1. Example case of land being threatened when it's cheap and un-threatened (left side) when it's expensive (right side).

- 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, we were to simulate buying process until T, we would have to simulate the market process until T' where $T < T'$ and $\delta, \rho \mapsto T'$