Optimizing Pollution Tax Policies
in Rural China

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Extended Abstract
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ABSTRACT
China's rapid period of industrialization created widespread rural pollution. This paper explores the efficacy and cost of emission reduction versus remediation tax policies. Modeling the effects of these initiatives on factory output, the spread of pollution is simulated over time. Whereas single-focus policies are neither effective nor cost-efficient, hybrid policies that both stymie further pollution and reverse damage to the land are stable long-term solutions.

CONTEXT

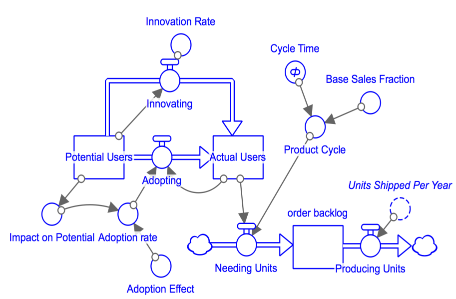
Through tax benefits and lax environmental standards, local governments incentivize the building of factories to grow their economy.[1,2,3,4] The resulting factory pollution contaminates land via wastewater.[3,5,6] Polluted land becomes infertile and uninhabitable, killing residents and the local farming industry.[5,7] As China currently is more than 250 million arable hectares below the "red line" needed to feed their population, rural pollution poses a threat to the long-term viability of the country.[1] We seek to find the optimal tax policy that reverses pollution at minimal cost.

MODELING APPROACH

Using historical smartphone sales,[8,9] we generated demand for a hypothetical smartphone product. We developed a supply chain in a fictitious village to fulfill the demand, and modeled the resultant pollution's effect on the land.

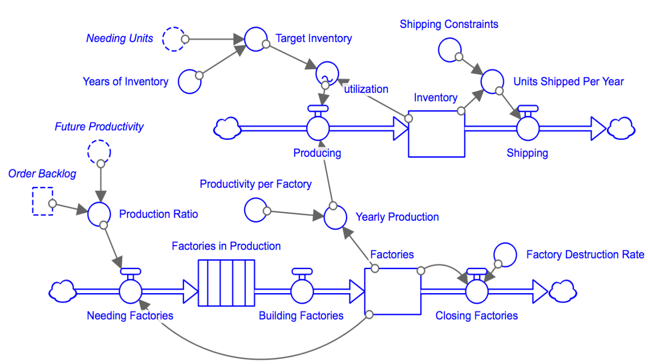
1. Smartphone Demand

Generate smartphone demand growth to equilibrium with oscillations using a Bass Diffusion Curve,[10] and a sinusoidal product cycle to represent current dynamics of product rollout in the electronics industry.[8,9]



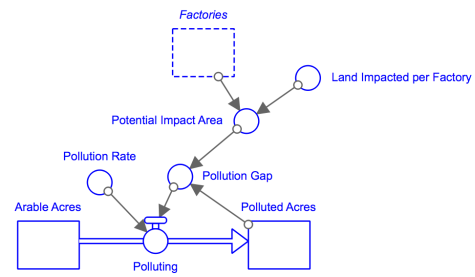
2. Supply Chain Dynamics

Create supply chain dynamics using stock-generated flows focusing on factory building and inventory management.[11,12]



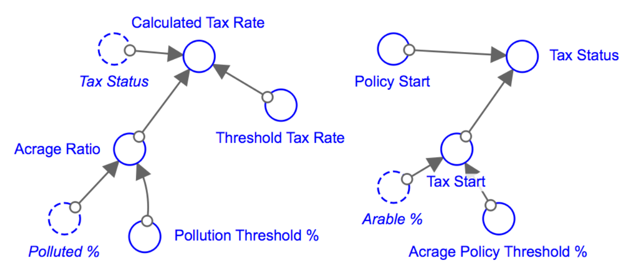
3. Spread of Pollution

Model pollution on the land with main chain of arable and polluted land driven by a stock adjustment process.[13]



4. Policy Implementation

Starting at 2018, if policies are enabled, a tax equal to the ratio between the percent of the polluted hectares and the pollution threshold will be levied.

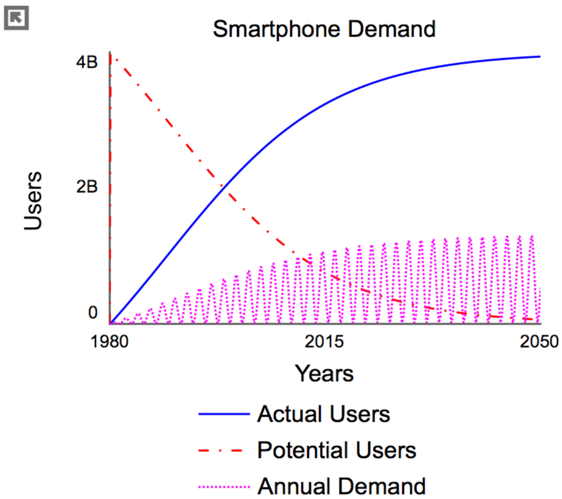


BASE CASE

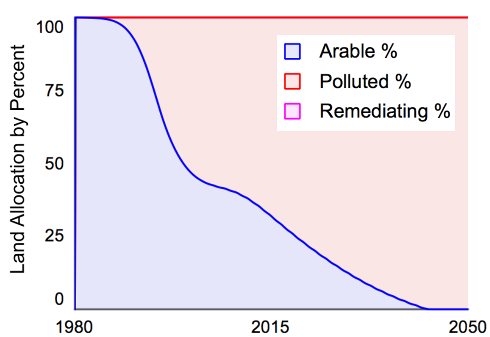
The effects of pollution are simulated given no policy intervention from 1980 to 2050.

Given that pollution data in China is notoriously hard to obtain,[1] the first order conditions (rate of pollution spread, specific policy cost per hectare, and duration of remediation) are based off of analogous values from countries that underwent similar modernization processes.[13,14]

Demand for the fictitious phone product follows a logistic growth curve and plateaus in 2030 to simulate market penetration of a new electronic product. The demand oscillates sinusoidally such that every 2 years each user buys a new phone to match a typical product cycle.[8,9,10]



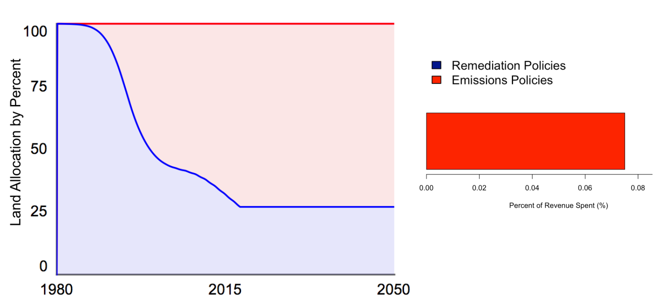
Through modeling the industrialization of a village during a technology boom, the number of factories converges to a plateau as demand becomes effectively constant. The number of arable hectares exponentially decays until the number of factories becomes constant, at which point it decays linearly.



The model behavior shows that given no policy interventions, the current land will continue deteriorating to its theoretical limit.

EMISSION REDUCTION POLICIES

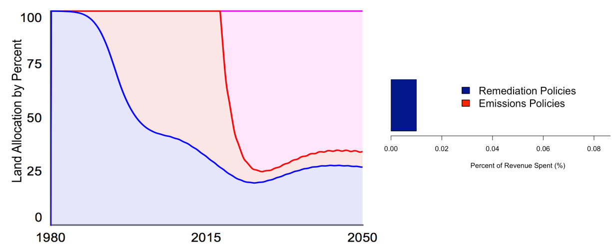
The effects of pollution are simulated from 1980 to 2050 with a tax beginning in 2018 fully allocated to emission reduction policies.



While these policies can halt further emissions at great cost, they cannot undo the historical pollution damage to the land.

REMEDIATION POLICIES

The effects of pollution are simulated from 1980 to 2050 with a tax beginning in 2018 fully allocated toward remediation.



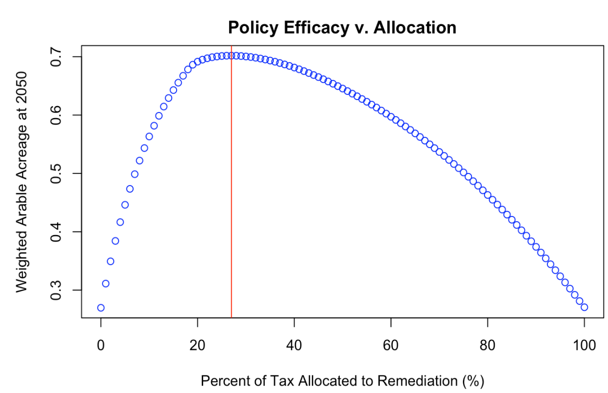
While these policies temporarily reverse the pollution, the remediated hectares quickly become polluted again. Thus, this policy is not stable over time as the progress is quickly undone.

OPTIMIZING POLICY COMBINATION

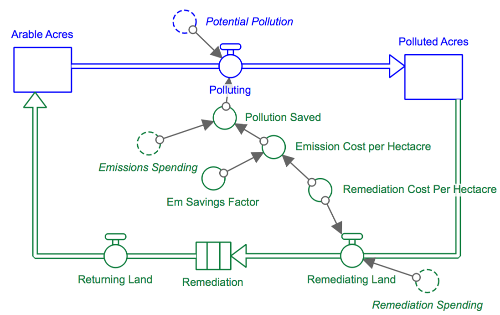
The optimal policy combination maximizes arable hectares with minimal tax cost generated by the following function:

$$\text{Weighted Arable Acreage} = (\%\ \text{Arable})\,\frac{\text{Revenue - Taxes}}{\text{Revenue}}$$

Testing different combinations of spending on remediation versus emission reduction policies beginning in 2018, we plot the resulting weighted arable acreage at 2050:



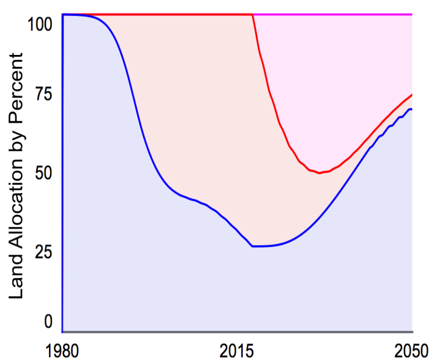
The model shows that the optimal policy allocates 28% of the tax spending towards remediation and 72% toward emission reduction policies. While this specific balance is the result of the assumptions behavior is observed regardless of the relative costs per hectare between the two strategies. Thus, while the precise numbers are irrelevant, the optimal policy combination is likely a balanced approach of emission reduction and remediation.

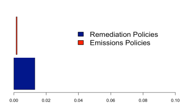


The model structure of land allocation is therefore amended to represent this optimal hybrid approach.

OPTIMAL TAX POLICY

The effects of pollution are simulated from 1980 to 2050 with a tax beginning in 2018 allocated 72% toward emission reduction and 28% toward remediation policies.





As this policy both halts further emissions and revitalizes polluted land, it increases arable land to a stable long-term level at minimal cost.

CONCLUSIONS

Emission reduction halts the inflow to polluted acreage but fails to reverse historical damage. Remediation policies revitalize land but don't stop further emissions, thus land continues to become polluted. Instituting these single-focused pollution policies is neither effective nor cost-efficient. While we cannot know the precise optimal balance given the assumptions made about the first order conditions, the model shows that hybrid policies are strictly better long-term solutions. Therefore, further research into exact precise remediation and emission reduction costs would enable us to remove assumptions and further fine-tune the optimal policy balance.

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