Centre for Energy and Environmental Markets

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Does penalty design matter for emissions trading markets? A laboratory investigation

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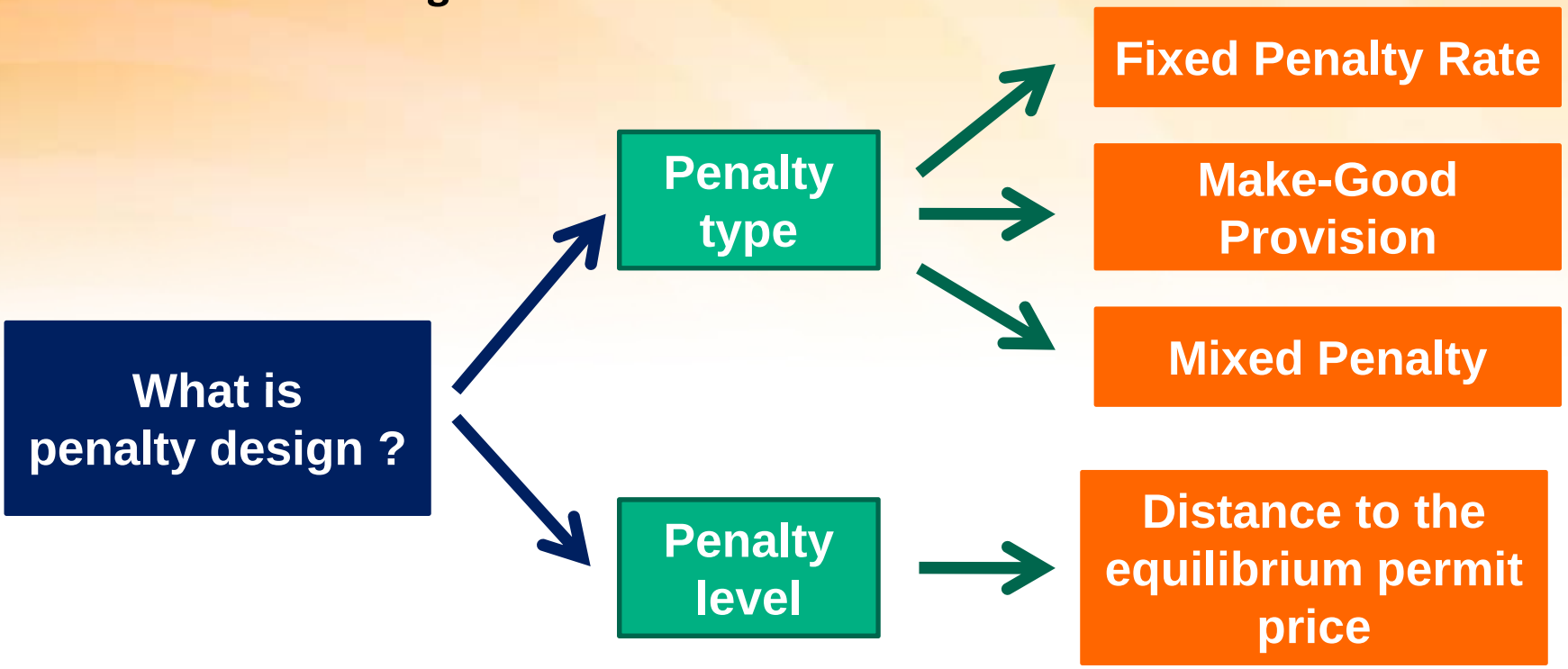
Motivation

Penalty design is a crucial element to achieve the environmental effectiveness of emissions trading markets



Existing studies

- **Experiment using dynamic enforcement, but penalty design is not a treatment variable (Cason Gangadharan 2006).**
- **Effect of targeted enforcement by applying different audit probability and penalty level (Stranlund 2007) . The results show that targeted enforcement does not increase the efficacy of enforcement. However the expected net buyers have higher non-compliance than the expected net sellers.**
- **In theory, when penalty rate is higher than permit price, firms will choose to be compliant by buying permits on the market or by reducing emissions.**
- **In practice, penalty level is normally set very high in practice to encourage higher compliance rates.**
- **Difficult to measure the effects of penalty design from empirical data due to different market structures of existing trading schemes.**

Research question

1. **Does penalty design affect price signals?**
2. **What are the effects of penalty design on the choice of compliance strategy and compliance rate**

   Two compliance strategies:
   1. **Irreversible investment decision, or**
   2. **Permit holding (buying permits)**
3. **How does penalty design influence efficiency?**

Experimental design

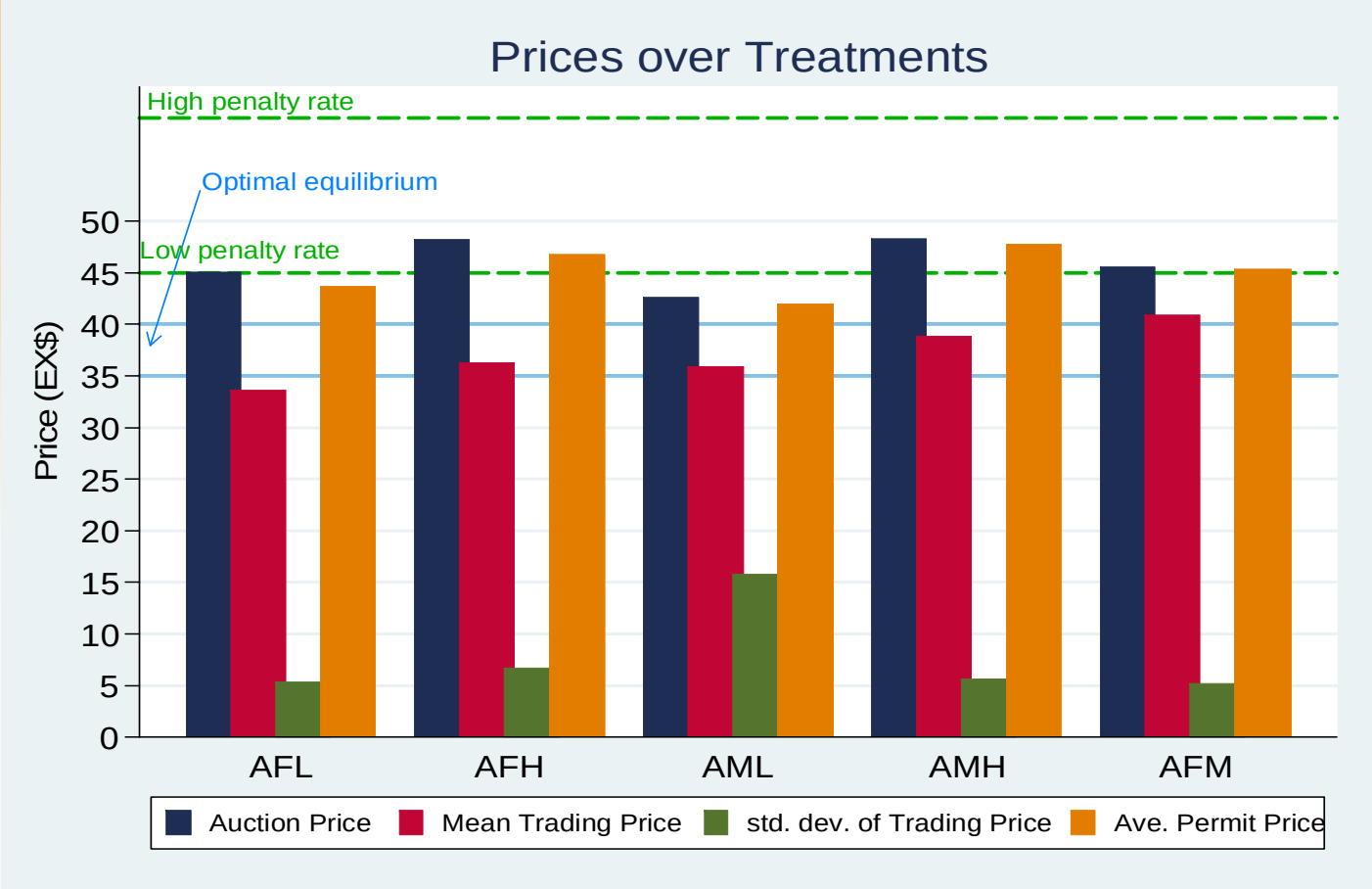
Penalty type	Penalty Level	
	Low Level	High Level
Fixed Penalty Rate (FPR)	1.2 Equilibrium Price **Treatment 1 (low FPR /AFL)**	3 x Equilibrium Price **Treatment 2 (high FPR / AFH)**
Make-Good Provision (MGP)	Make-good ratio 1:1 **Treatment 3 (low MGP / AML)**	Make-good ratio 3:1 **Treatment 4 (high MGP / AMH)**
Mixed of FPR & MGP	Low Make-Good Provision and Penalty Rate Linked to Auction (1.2 x Auction Price) **Treatment 5 (Mixed Penalty / AFM)**	

- **2 experiment tasks in each session:**
  - **Risk preference assessment with Holt & Laury (2002) lottery choice decision**
  - **Market game**
- **Control questions and one Practice round**
- **6 sessions for each treatment, total of 240 subjects**
- **Each session lasts 2-2.5 hours, average payoff A$ 34.20**

Key market features

- **6 repeated rounds, each with 2 Sub Periods → 12 periods**
- **Stages in the experiment:**
  1. **Auction of permits: ascending clock auction**
  2. **Permit trading: continuous double auction**
  3. **Investment decision (only in Sub Period 1): no partial investment is allowed**
  4. **Compliance check**
- **Players characters :**
  - **8 identical firms → 4 high Marginal Abatement Cost (MAC) firms (net buyer) & 4 low MAC firms (net seller)**
  - **same structure of MAC in each round {20,55} for all, shuffled for each subject**
  - **Same endowment across players and fixed emission levels**
- **Banking and borrowing are not allowed (permit expires in each sub period)**
- **Enforcement of penalty**
  - **Fixed Penalty Rate: Immediate deduction at the end of each sub period**
  - **Make-Good Provision:**
    - **Sub period 1: quantity compensation of the missing licenses**
    - **Sub period 2: a deduction that equals to total revenue in that sub period**

Result: auction price

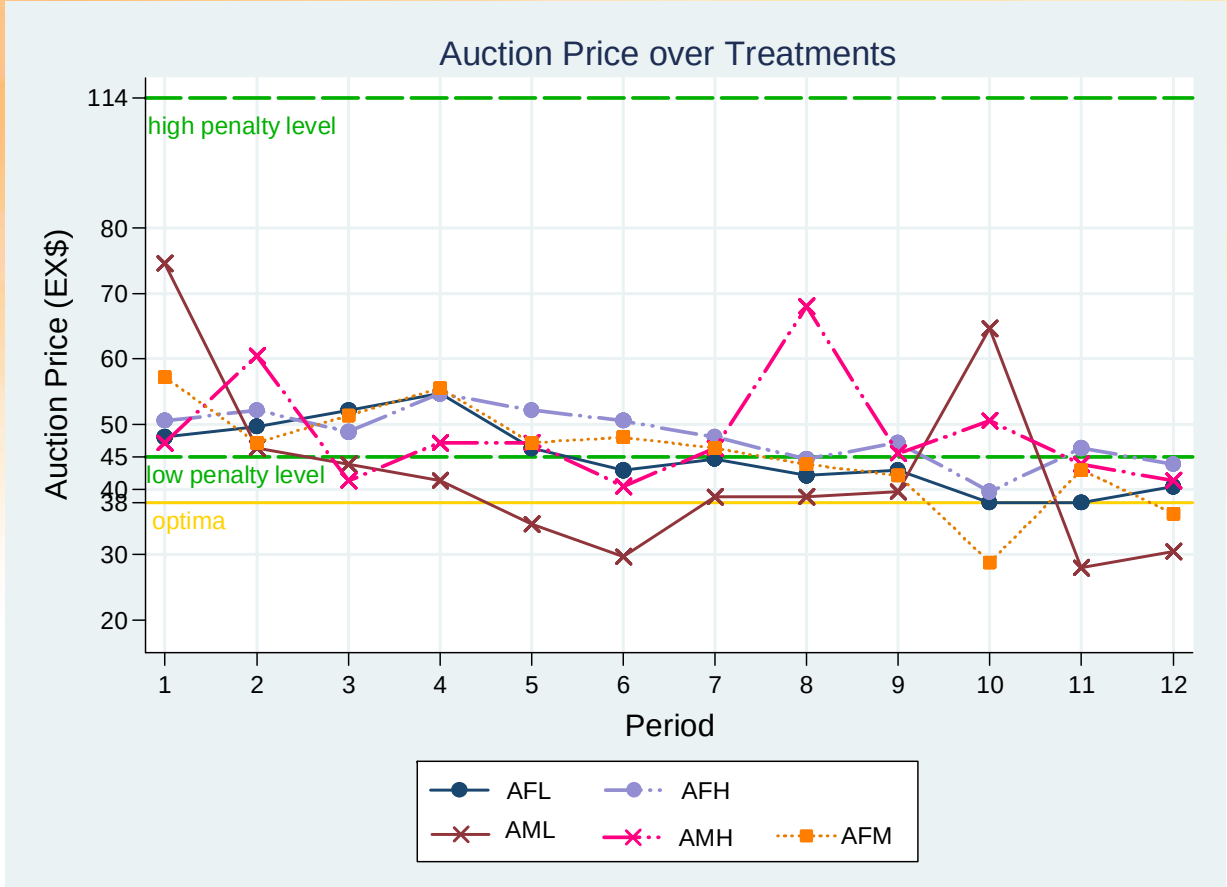


Notes: AFL= Auction Fixed Penalty Rate Low Level AFH= Auction Fixed Penalty Rate high Level

AML= Auction Make-Good Provision Low Level AMH= Auction Make-Good Provision High Level

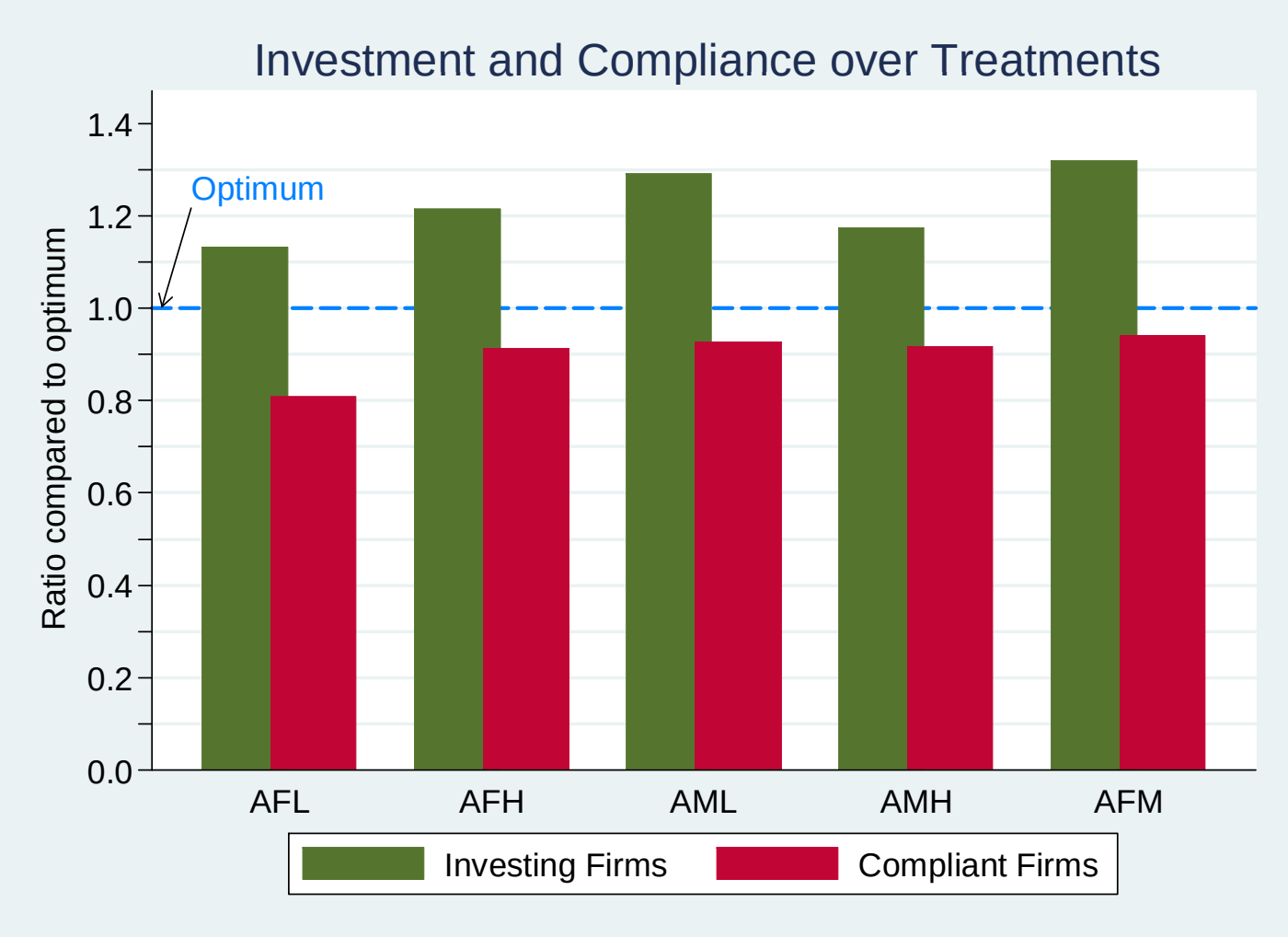
AFM =Auction Mix of FPR & MGP

Result 1: Effect of penalty design on auction price

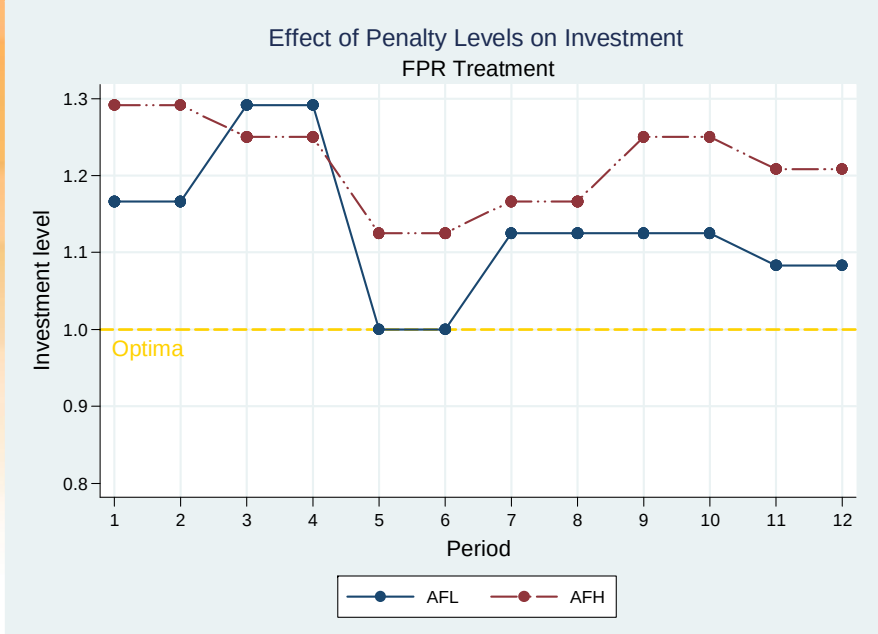


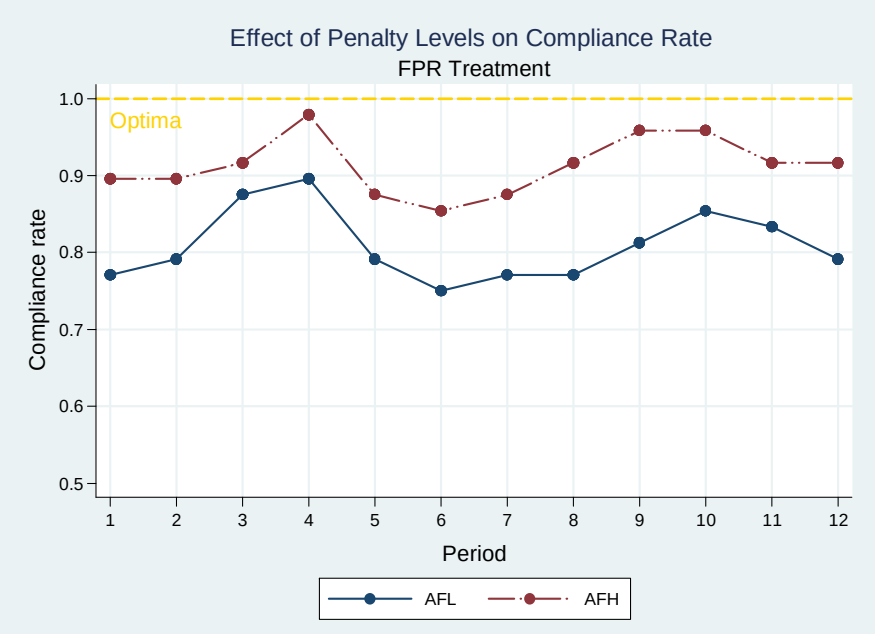
- **Auction prices remain above the optimal level**
- **No treatment effects on auction price (p-value= 0.1537)**

Result: compliance strategy and compliance rate



Result 2: Effect of penalty levels in FPR treatment

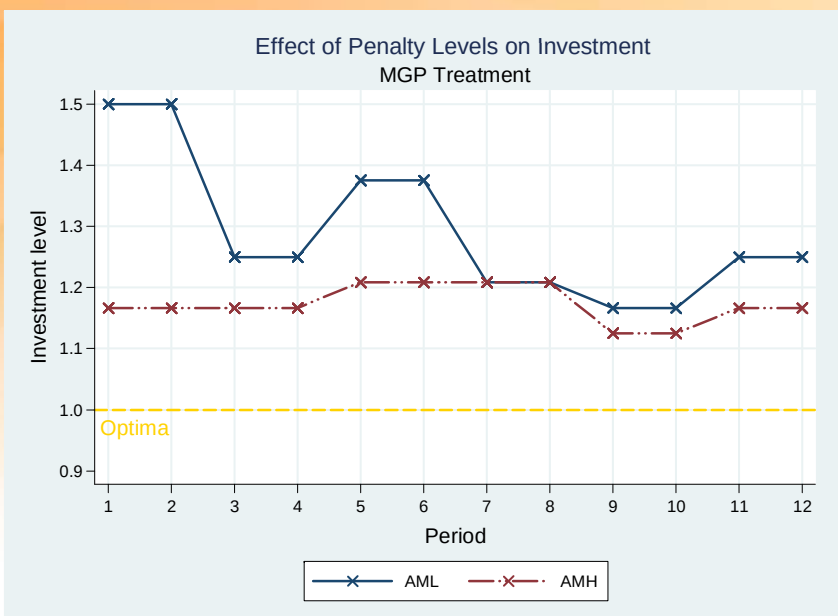


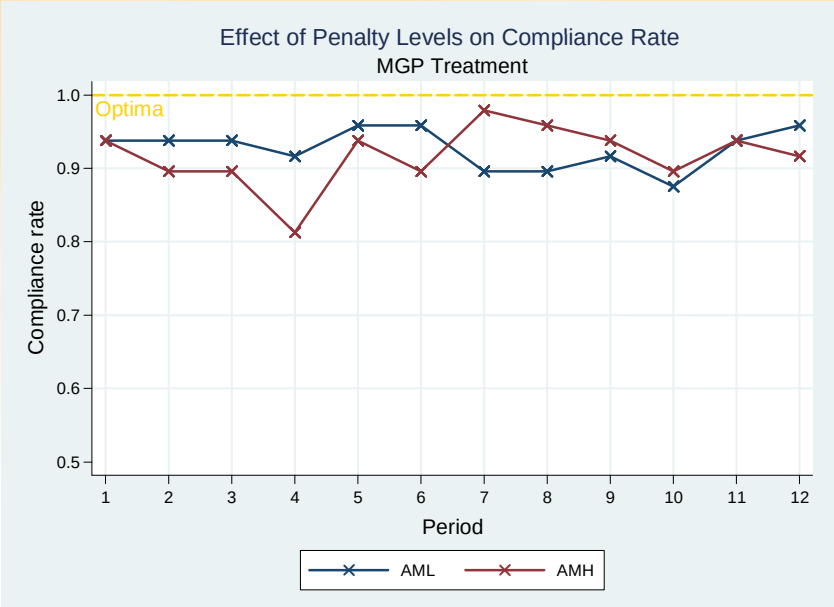


- **No treatment effect of penalty levels on investment levels (KS p-value = 0.419)**

- **Higher compliance rate in high FPR treatment (KS p-value= 0.001)**

Result 3: effect of penalty levels in MGP

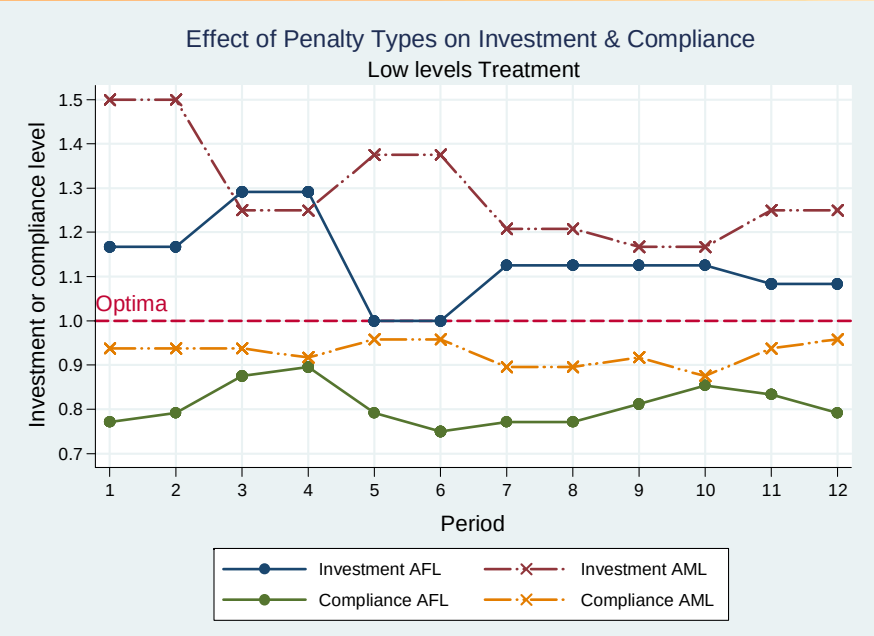


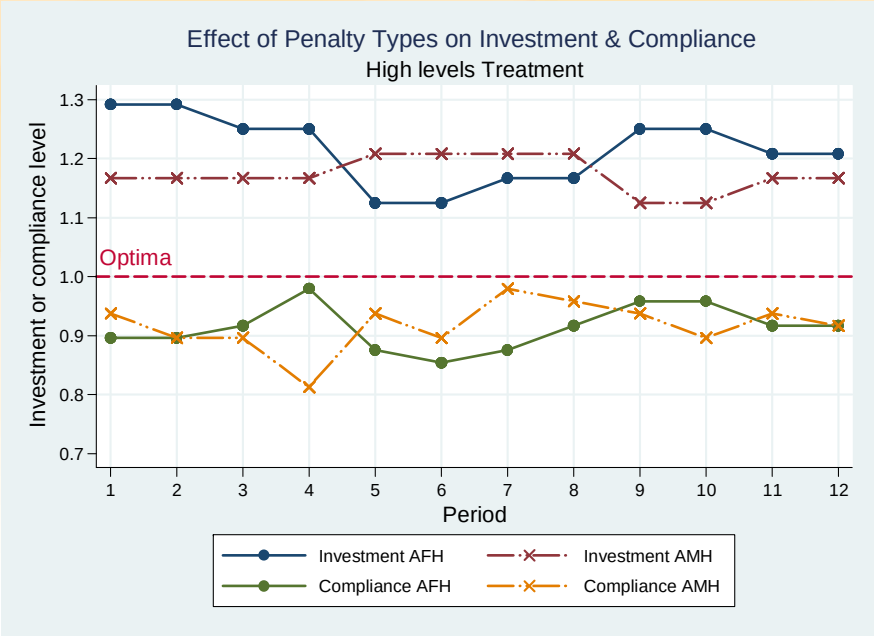


- **No treatment effect of penalty levels in MGP on investment levels (KS p-value = 0.419)**

- **No treatment effect of penalty levels in MGP on compliance rate (KS p-value= 1.000)**

Result 4: effect of penalty types

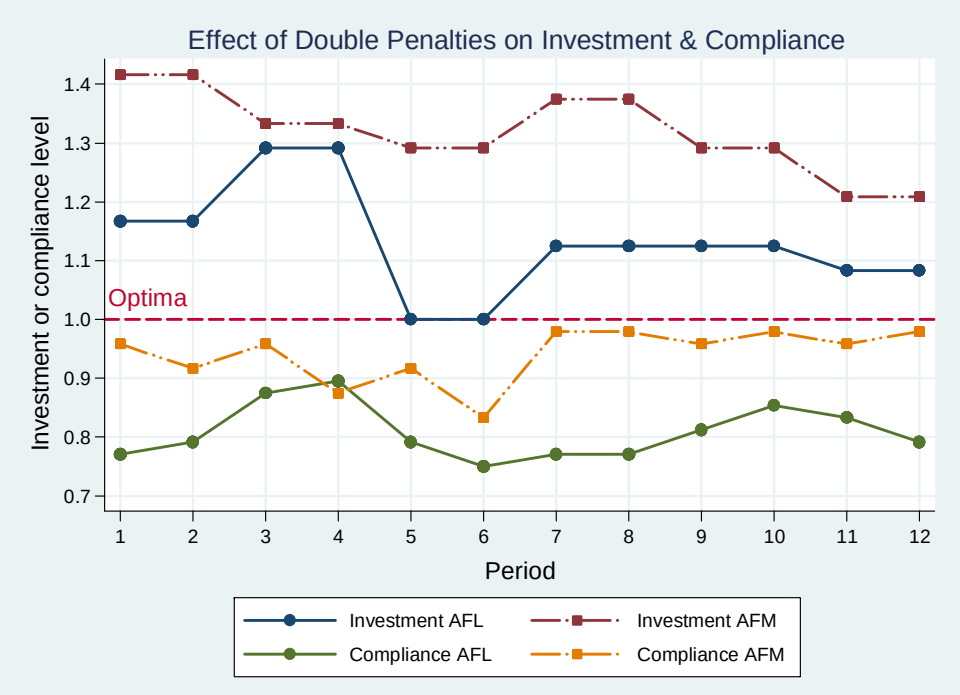




- **No treatment effect of penalty types on compliance strategy in low levels treatment (KS p-value = 0.213)**
- **Higher compliance rate in low MGP compared to low FPR (KS p-value = 0.000)**

- **No treatment effect of penalty types on investment levels (KS p-value = 1.000) and compliance rate (KS p-value = 1.000) in high levels treatment**

Result 5: effect of double penalties (mixed penalty)



- **Higher investment level (KS p-value = 0.014) and higher compliance rate (KS p-value = 0.000) in Mixed Penalty (AFM) compared to low FPR treatment**

Inferences from random effect regression models

1. **Auction Price**
   - **Penalty design variables are not significant**
   - **Learning effect is confirmed**
   - **Risk-related variables are significant after controlling for demographic variables**
2. **Investment decision**
   - **MGP treatment is the only significant penalty design variables.**
   - **Firm made rational investment behaviour as indicated by firm type and permit position**
   - **Auction price has positive effect on investment decision**
3. **Compliance decision through permit buying (non-investing firms)**
   - **Penalty rate and MGP treatment have significantly positive effect on compliance**
   - **Auction price has negative effect on investment decision, but not trading price**
4. **Efficiency**
   - **While compliance increases efficiency, opposite effect is produced by investment**
   - **Learning effect is also significant**

Conclusions

- **Higher penalty level provides higher compliance incentive**
- **Mixed Penalty design induces higher compliance rate compared to low FPR treatment.**
- **Risk related variables, rather than penalty design, affect auction price. Auction price acts as the main price signal which determines compliance strategy as well as efficiency**
- **MGP penalty type has significant effects on compliance strategy (investment decision and compliance through permit buying).**
- **There is a trade-off between efficiency and compliance incentives since MGP penalty type correlates to both higher investment and compliance rate, and yet to lower efficiency.**

Thank you

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