# Economic Model for Stubble Burning in India: A Keynesian Framework

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**Abstract**

Stubble burning in Punjab and Haryana presents significant environmental and health challenges. This paper develops a Keynesian economic model to analyze the equilibrium between stubble burning and alternative methods, integrating the role of government intervention, central bank policies, and trade variables. By solving the model step by step, it provide insights into how fiscal and monetary policies can optimize social welfare and address externalities associated with stubble burning.

## 1 Introduction

Stubble burning is a prevalent agricultural practice in India, primarily used by farmers to quickly clear fields after harvest. While this method is cost-effective and efficient, it results in severe environmental consequences, including air pollution and health hazards for nearby populations. The harmful effects of stubble burning contribute to poor air quality, respiratory issues, and long-term ecological damage, making it a pressing public health and environmental concern.

This paper applies a Keynesian framework to analyze the equilibrium state of stubble burning, considering key factors such as government fiscal policies, central bank interest rates, and trade variables. By modeling these interactions, we aim to understand how these elements influence farmers' decisions and identify effective policy measures to mitigate the practice of stubble burning.

The objective is to provide insights into how financial incentives, penalties, and macroeconomic conditions can alter farmers' behavior, leading to a

reduction in stubble burning and its associated costs. Ultimately, this analysis seeks to inform policymakers and stakeholders about the importance of integrating economic theories into practical solutions for sustainable agricultural practices in India, fostering both environmental preservation and economic stability.

# 2 Theoretical Framework

The theoretical framework for this model is grounded in Keynesian economics, which emphasizes the role of aggregate demand in influencing economic outcomes. The framework integrates several key concepts and relationships that govern the decision-making process of farmers regarding stubble burning and alternative agricultural practices.

## 2.1 Cost-Benefit Analysis

At the core of farmers' decisions is a cost-benefit analysis comparing the total costs of stubble burning to the costs of alternative methods. This relationship is formalized in the equation:

$$C_{sb} + P = C_{alt} - S \tag{1}$$

where $C_{sb}$ represents the direct costs of stubble burning, $P$ is the penalty, $C_{alt}$ is the cost of alternatives, and $S$ is the subsidy. Farmers will choose stubble burning if the total cost, including penalties, is less than or equal to the net cost of alternatives.

## 2.2 Government Intervention

The model recognizes the critical role of government policies in influencing farmer behavior. Subsidies ($S = \alpha \cdot G$) are proportional to government expenditure ($G$), while penalties ($P = \beta \cdot T$) are linked to tax revenues ($T$). By adjusting these variables, the government can affect the financial attractiveness of alternative methods.

## 2.3 Aggregate Demand Dynamics

The framework also incorporates aggregate demand, expressed as:

$$AD = C + I + G + (X - M) \tag{2}$$

Changes in consumption, investment, government spending, and net exports impact overall economic activity, influencing farmers' decisions and the equilibrium state of stubble burning.

### 2.4 Central Bank Influence

The central bank's role in setting interest rates affects investment expenditures, represented as:

$$I = I_0 - \gamma \cdot R \tag{3}$$

Higher interest rates make borrowing more expensive, discouraging investment in sustainable technologies.

### 2.5 Social Costs

Finally, the model accounts for the total social cost (TSC) associated with stubble burning, including health and environmental impacts. This broader perspective underscores the importance of minimizing social costs through effective policy interventions that promote sustainable practices.

By integrating these concepts, the theoretical framework provides a comprehensive understanding of the factors influencing stubble burning and offers a basis for evaluating policy interventions aimed at promoting sustainable agricultural practices.

## 3 Model Framework

### 3.1 Key Variables

- $C_{sb}$: Direct cost of stubble burning (excluding penalties).
- $P$: Penalty imposed on stubble burning.
- $C_{alt}$: Cost of using alternative methods.
- $S$: Subsidy for using alternative methods.

- $Q$: Quantity of stubble burned.
- $Y$: Aggregate income (output) in the economy.
- $G$: Government expenditure on subsidies.
- $T$: Tax revenue used for penalties.
- $M$: Imports.
- $X$: Exports.
- $I$: Investment expenditure.
- $C$: Consumption expenditure.
- $R$: Interest rates set by the central bank.

## 3.2 Farmers' Decision

Farmers will compare the effective cost of stubble burning with the cost of alternative methods:

$$C_{sb} + P = C_{alt} - S \tag{4}$$

**Interpretation:** This equation represents the farmers' decision-making process. They will opt for stubble burning if its total cost (including penalties $P$) is less than or equal to the cost of using alternative methods (after accounting for subsidies $S$).

Substitute $S$ and $P$:

$$S = \alpha \cdot G \tag{5}$$

$$P = \beta \cdot T \tag{6}$$

Thus, the equilibrium condition becomes:

$$C_{sb} + \beta \cdot T = C_{alt} - \alpha \cdot G \tag{7}$$

**Interpretation:**

- $S = \alpha \cdot G$: The subsidy $S$ is proportional to government expenditure $G$. Higher government spending on subsidies makes alternative methods more financially attractive to farmers. Here, alpha is proportionality constant.

- $P = \beta \cdot T$: The penalty $P$ is proportional to the tax revenue $T$. Higher penalties increase the cost of stubble burning, making it less attractive compared to alternatives. Here, beta is proportionality constant.

The flowchart effectively illustrates the various factors influencing farmers' decisions about stubble burning versus alternative agricultural practices, emphasizing the costs and incentives (subsidies) involved in the decision-making process. It provides a clear visual representation of the equilibrium model's components and their relationships. The diagram is shown below:

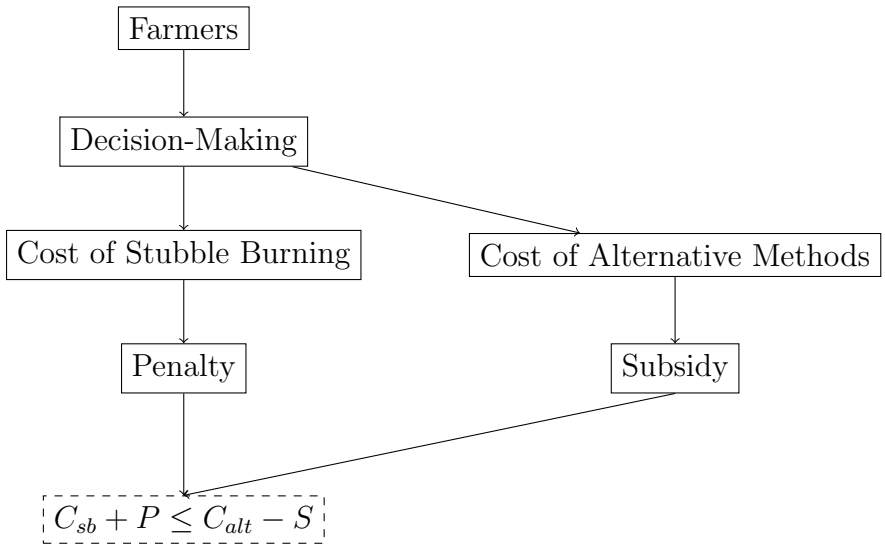


Figure 1: Equilibrium Model for Stubble Burning

## 3.3 Aggregate Demand

Aggregate demand ($AD$) is influenced by consumption, investment, government spending, and net exports:

$$AD = C + I + G + (X - M) \tag{8}$$

**Interpretation:** Aggregate demand includes total spending in the economy. It comprises consumption ($C$), investment ($I$), government spending ($G$), and net exports (exports $X$ minus imports $M$). Changes in these components affect overall economic activity and, consequently, the equilibrium between stubble burning and alternative methods.

## 3.4 Central Bank's Role

The central bank affects investment ($I$) through interest rates ($R$):

$$I = I_0 - \gamma \cdot R \tag{9}$$

where $I_0$ is the baseline investment and $\gamma$ represents sensitivity to interest rates.

**Interpretation:**

- $I = I_0 - \gamma \cdot R$: Investment $I$ decreases as interest rates $R$ increase. Higher interest rates make borrowing more expensive, reducing investment. This relationship affects the availability of funds for alternative methods to stubble burning.

## 3.5 Total Social Cost (TSC)

The total social cost considers the direct cost of stubble burning, health, and environmental costs:

$$TSC = Q \times (C_{sb} + P) + \text{Health Costs} + \text{Environmental Costs} \tag{10}$$

**Interpretation:**

- $TSC = Q \times (C_{sb} + P)$: This term represents the total cost of stubble burning, including both direct costs and penalties, multiplied by the quantity of stubble burned ($Q$).
- Health Costs and Environmental Costs: Additional costs incurred by society due to pollution and health issues caused by stubble burning. These are included to capture the full impact of stubble burning on social welfare.

### 3.6 Trade Variables

**Exports ($X$)**: Exports contribute positively to aggregate demand:

$$AD_X = \text{Export Revenue} = \text{Price of Exports} \times X \tag{11}$$

**Interpretation:** Exports $X$ increase aggregate demand. Higher export revenue boosts overall economic activity, which can influence the allocation of resources and the attractiveness of alternatives to stubble burning.

**Imports ($M$)**: Imports reduce aggregate demand as they represent spending outflows:

$$AD_M = \text{Import Spending} = \text{Price of Imports} \times M \tag{12}$$

**Interpretation:** Imports $M$ decrease aggregate demand. Increased spending on imports represents an outflow of economic resources, reducing the funds available for domestic investment in alternatives to stubble burning.

## 4 Solving the Model

### 4.1 Step 1: Express the Equilibrium Condition

From the equilibrium condition:

$$C_{sb} + \beta \cdot T = C_{alt} - \alpha \cdot G \tag{13}$$

### 4.2 Step 2: Incorporate Aggregate Demand

Using aggregate demand equation:

$$AD = C + (I_0 - \gamma \cdot R) + G + (X - M) \tag{14}$$

### 4.3 Step 3: Central Bank Influence

Investment function related to interest rates:

$$I = I_0 - \gamma \cdot R \tag{15}$$

## 4.4 Step 4: Solve for Quantity of Stubble Burned ($Q$)

To find the equilibrium quantity of stubble burned ($Q^*$):

1. **Determine $G$ and $T$ from the equilibrium condition:**

$$\alpha \cdot G + \beta \cdot T = C_{alt} - C_{sb} \tag{16}$$

**Interpretation:** This equation helps in calculating the necessary government expenditure and tax revenue to balance the cost of stubble burning and alternatives.

2. **Substitute $G$ and $T$ into the aggregate demand equation:**

$$AD = C + (I_0 - \gamma \cdot R) + G + (X - M) \tag{17}$$

**Interpretation:** Aggregate demand is affected by the components adjusted for government policies, interest rates, and trade variables. Ensuring a balance here supports overall economic stability and influences the optimal amount of stubble burning.

3. **Calculate $Q$ using the cost equations:**

$$Q^* = \frac{C_{alt} - C_{sb} - \alpha \cdot G + \beta \cdot T}{\text{Cost per unit}} \tag{18}$$

**Interpretation:** This equation calculates the equilibrium quantity of stubble burned by balancing the cost of stubble burning and alternatives, incorporating the effects of subsidies and penalties.

## 4.5 Step 5: Optimize Social Welfare

Minimize $TSC$:

$$\text{Minimize } TSC = Q^* \times (C_{sb} + \beta \cdot T) + \text{Health Costs} + \text{Environmental Costs} \tag{19}$$

**Interpretation:** To achieve optimal social welfare, adjust $G$, $T$, $R$, $X$, and $M$ to minimize the total social cost of stubble burning.

## 4.6 Equilibirium Analysis[1]

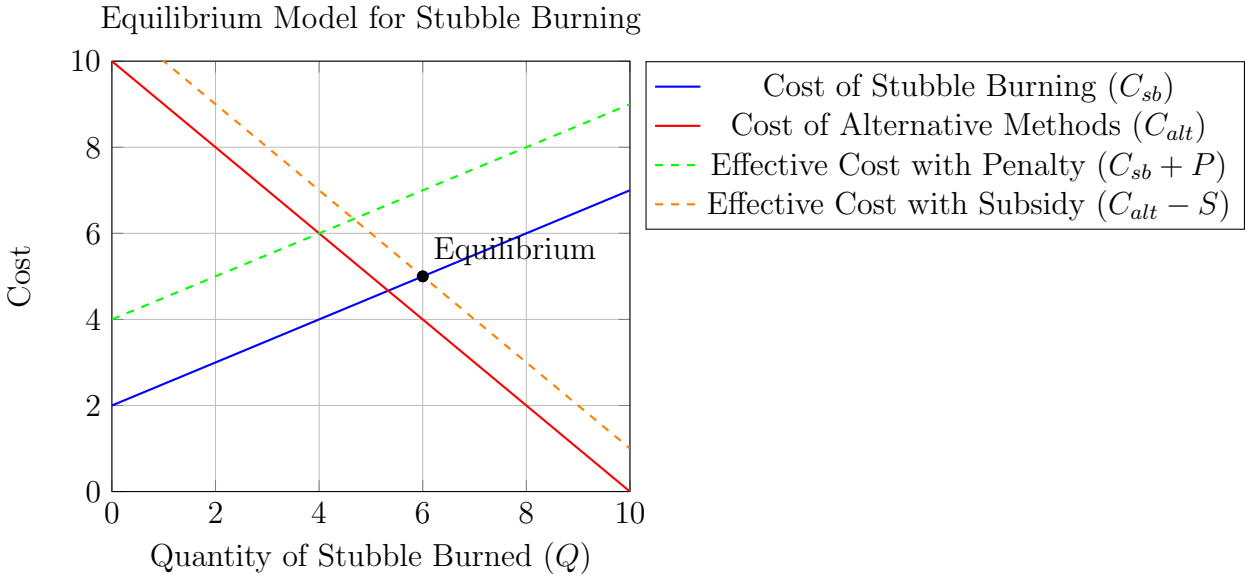


Figure 2: Graphical Representation of the Equilibrium Model for Stubble Burning

The equilibrium of the graph represents the critical point where the costs associated with stubble burning equal the effective costs of alternative methods, factoring in penalties and subsidies. Here's a detailed explanation:

## 4.7 Components of the Graph

1. **Axes**:

   - **Horizontal Axis ($Q$)**: Represents the quantity of stubble burned. As this quantity increases, the graph shows how costs change.
   - **Vertical Axis (Cost)**: Represents the various costs associated with stubble burning and alternative methods.

2. **Curves**:

[1]The plot number mentions on the graph, are hypothetical in nature

- **Cost of Stubble Burning ($C_{sb}$)**: The blue line shows that the cost of stubble burning increases linearly with the quantity burned, indicating that as more stubble is burned, the direct costs (e.g., labor, equipment) rise.

- **Cost of Alternative Methods ($C_{alt}$)**: The red line indicates a decreasing cost for alternative methods as the quantity handled increases, reflecting potential efficiencies or economies of scale.

- **Effective Cost with Penalty ($C_{sb} + P$)**: The green dashed line illustrates the total cost of stubble burning when penalties are included, effectively raising the cost of burning stubble and making it less attractive.

- **Effective Cost with Subsidy ($C_{alt} - S$)**: The orange dashed line represents the effective cost of using alternative methods after accounting for subsidies, making alternatives more financially appealing.

## 4.8 Equilibrium Point

- **Intersection**: The equilibrium point is where the blue line (Cost of Stubble Burning) intersects with the orange dashed line (Effective Cost with Subsidy). This point indicates the quantity of stubble burned at which the total cost of burning equals the effective cost of using alternative methods. At this intersection, farmers are indifferent between the two choices because the costs are balanced.

## 4.9 Economic Interpretation

1. **Decision-Making**: At the equilibrium point, farmers will choose to burn stubble if the total cost of stubble burning (including penalties) is less than or equal to the cost of alternatives after subsidies are considered. If the cost of burning increases (e.g., through higher penalties), or if the subsidies for alternatives increase, the equilibrium point shifts.

2. **Policy Implications**: Policymakers can influence this equilibrium by adjusting penalties and subsidies. For example, increasing the penalties for burning stubble will raise the effective cost of burning, potentially leading farmers to adopt alternative methods more readily. Conversely, enhancing

subsidies for alternatives will lower their effective cost, encouraging farmers to opt for these methods over burning.

3. **Environmental Impact**: Achieving an equilibrium at a lower quantity of stubble burned is beneficial for the environment. It indicates a shift towards sustainable practices, reducing the pollution and health hazards associated with stubble burning.

# 5 Policy Recommendations as per Model

1. **Increase Penalties for Stubble Burning:**
   - Implement higher penalties proportional to the tax revenue ($P = \beta \cdot T$) to disincentivize stubble burning.
   - This will make stubble burning financially unattractive to farmers, encouraging the adoption of alternative methods.
2. **Enhance Subsidies for Sustainable Practices:**
   - Increase government expenditure on subsidies for alternative methods ($S = \alpha \cdot G$) to lower their cost.
   - Higher subsidies reduce the financial burden on farmers, making eco-friendly options more viable.
3. **Adjust Central Bank Interest Rates:**
   - Lower interest rates to stimulate investment ($I = I_0 - \gamma \cdot R$) in sustainable agricultural practices and technologies.
   - Affordable credit would enable farmers to invest in alternatives to stubble burning, such as crop residue management equipment.
4. **Promote Trade Policies Favoring Sustainability:**
   - Implement trade policies that encourage the export of environmentally friendly agricultural products, boosting demand for sustainable farming practices.
   - Regulate imports to ensure that domestic resources are allocated toward eco-friendly alternatives and that external competition does not undermine sustainability goals.

5. **Support Farmers with Financial Incentives:**
    - Introduce financial incentives such as low-interest loans, grants, and insurance for farmers adopting sustainable methods.
    - This would reduce the upfront cost of transitioning from stubble burning to alternative methods and enhance long-term productivity.
6. **Integrate Environmental Costs into Policy:**
    - Factor in health and environmental costs associated with stubble burning into fiscal policies, ensuring that the true social cost is accounted for in decision-making.
    - Prioritize policies that minimize total social cost (TSC), aiming to reduce both direct and indirect consequences of stubble burning.

# 6 Conclusion

This Keynesian model of stubble burning, which integrates government fiscal policies, central bank interest rates, and trade variables, provides a comprehensive framework for understanding farmers' decision-making processes. By balancing the costs of stubble burning and alternative methods, this model emphasizes the importance of targeted policy interventions. Key variables such as subsidies, penalties, and interest rates directly influence farmers' choices, while broader macroeconomic factors like aggregate demand and trade dynamics shape the overall economic environment in which these decisions occur.

Effective policy interventions, such as increasing penalties, enhancing subsidies for sustainable alternatives, and adjusting interest rates to promote investment in eco-friendly practices, can significantly reduce the practice of stubble burning. Moreover, trade policies that favor sustainable agricultural exports and manage imports can further support environmental goals. The model underscores the importance of minimizing the total social cost, including environmental and health impacts, in the pursuit of sustainable agricultural practices.

In conclusion, coordinated efforts between fiscal policy, monetary policy, and trade management can optimize farmer behavior and reduce

stubble burning. This holistic approach not only improves environmental and public health outcomes but also fosters long-term economic stability by encouraging sustainable agricultural practices.

# 7 Way Forward

To enhance the current model, several key extensions should be considered. First, introducing time-based variables would allow for a dynamic approach, capturing the delayed effects of subsidies and penalties on farmers' decisions. This adjustment can better reflect how policy changes influence behavior over time.

Second, incorporating regional variations is essential, as different areas in India face unique agricultural and economic conditions. Factors like local crop cycles, government policies, and weather patterns can refine the model's applicability. Additionally, integrating a social behavior component that accounts for peer influence and community practices would enrich the analysis by incorporating insights from behavioral economics.

Moreover, incorporating environmental feedback mechanisms by integrating real-time data—such as air quality indexes and soil health metrics—would enable the model to dynamically adjust social costs and optimize policy interventions based on current conditions.

Lastly, exploring international cooperation on technology sharing and trade policies could broaden the model's scope, providing insights into how global efforts can help reduce stubble burning domestically. These enhancements will create a more comprehensive and adaptable framework for understanding and addressing the complex issue of stubble burning in India.

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