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Kruse-Andersen, Peter K.

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Peter K. Kruse-Andersen

Department of Economics, University of Copenhagen, Denmark

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A B S T R A C T

Historical events underscore that heavy reliance on foreign fossil fuel supply may come at a national security cost. The present study derives the optimal policy of a net fossil fuel importing economy with a binding climate target, when fossil fuel imports are associated with national security costs. The study shows that optimal carbon taxes are differentiated across fossil fuels and that domestic fossil fuel production should be subsidized. Further, carbon capture and storage should be taxed, while no subsidies should be granted to green energy production. These results contrast the typical climate policy recommendation of uniform carbon taxation.

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1. Introduction

Historical events like the 1973 oil embargo against the US and the Russia–EU gas dispute of 2022 underscore the interdependence of national security and energy supply. Meanwhile, it has become increasingly evident that we need to substantially reduce our dependency on fossil fuels to mitigate climate change. However, climate change and national security issues may conflict. The EU’s current dependency on Russian natural gas is, for instance, partly caused by the EU’s climate ambitions which incentivize fuel switching from coal to natural gas.

The present study examines the interaction between climate change ambitions and national security issues using an economic model. We derive the optimal climate policy for an economy that is a net fossil fuel importer with a binding climate target, and where the imports of different fossil fuels are associated with national security costs. These security costs reflect a sole economic understanding of energy supply is insufficient, as a growing dependency on foreign energy supply may result in insecurity issues (Baumann, 2008).

The optimal allocation can be achieved using two instruments: carbon taxes and subsidies for domestic energy production. However, the carbon taxes must be differentiated across fossil fuels, i.e. higher carbon taxes for fuels associated with stronger national security concerns. The domestic energy production subsidies are only granted to fossil fuels, as the carbon taxes provide sufficient incentive for green energy production. These policy implications contrast the typical climate policy recommendation of uniform carbon taxation.

The optimal allocation can also be implemented using carbon taxes and import tariffs on fossil fuels associated with national security costs (see online appendix). The tariffs increase domestic fossil fuel prices, increasing domestic production and reducing domestic consumption, thereby working as both production subsidies and carbon taxes. Nevertheless, we find it unlikely that import tariffs on fossil fuels motivated by national security concerns can be implemented in times of peace under GATT, Article XXI (see Reinsch, 2019). Thus, this policy option is probably incompatible with WTO rules. The present study, therefore, focuses on the case where the optimal allocation is implemented without tariffs.

This is – to our knowledge – the first study to derive an optimal climate policy that incorporates a national security dimension in a formal economic model. The present study contributes to an extensive literature on energy security (see Ang et al., 2015). These studies often quantify energy security, while optimal policies are seldom derived. The closest related study is Griffin and Steele (1986), who argue that market prices for oil do not reflect the security premium that follows from the risk of an oil embargo. They show that this market failure can be corrected using import tariffs. Yet, they do not consider any climate-related issues.

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Our study also relates to the carbon leakage literature. Optimal unilateral climate policies affect carbon leakage indirectly through international markets using border carbon adjustments (Hoel, 1996) or a variety of other policy instruments (Kruse-Andersen and Sørensen, 2022). In the present study, it is also optimal to affect international markets, but the concern links directly to net imports, whereas carbon leakage concerns the behavior of the foreign economy.

Finally, the present study contributes to the literature on issue linkage, as climate change mitigation is linked to national security concerns (see Maggi, 2016). Given that the optimal allocation may, in principle, be achieved through import tariffs, the present study also relates to studies on climate change mitigation and tariff policies (e.g., Barrett, 1997; Nordhaus, 2015; Farrokhi and Lashkaripour, 2021).

2. Model analysis

The general model structure borrows from Kruse-Andersen and Sørensen (2021) but adds multiple fossil fuel types.

2.1. Market economy

A representative firm produces final goods under perfect competition and maximizes profits, \( \pi^x \):

\[
\max_{n,b_1^i, \ldots, b_J^i, g^i} \pi^x = f(n, e^i (b_1^i, \ldots, b_J^i, g^i)) - nw - \sum_{j=1}^{J} b_j^i (p_j^i + r_j^{bx}) - g^i (p^x - s^g), \quad j = 1, 2, \ldots, J
\]

where \( f \) is the production of final goods, the price of final goods is normalized to one, \( n \) is the labor input, \( e^i \) is the energy service input, \( b_j^i \) is the fossil-based energy input of type \( j \) (e.g., natural gas), \( g^i \) is the green energy input, \( w \) is the wage rate, \( p_j^i \) is the unit price of fossil-based energy input \( j \), \( p^x \) is the unit price of the green energy input, the \( r \) variables are emission taxes, and \( s^g \) is a unit subsidy to green energy consumption. The functions \( f \) and \( e^i \) are increasing and concave in each argument.

Units are chosen such that burning one unit of fossil energy input results in one unit of emission. Hence \( r_j^{bx} \) is the unit emission tax on input \( j \).

A representative household maximizes utility, \( u \), subject to a budget constraint:

\[
\max_{x^h, b_1^h, \ldots, b_J^h, g^h} u(x^h, e^h (b_1^h, \ldots, b_J^h, g^h))
\]

subject to:

\[
w n + T = x^h + \sum_{j=1}^{J} b_j^h (p_j^h + r_j^{bh}) + g^h (p^x - s^gh),
\]

where \( x^h \) and \( e^h \) measure final goods and energy service consumption, \( b_j^h \) is the fossil-based energy service of type \( j \), \( g^h \) is green energy service, \( T \) is government transfers and profit earnings, the \( r \) variables are carbon taxes, and \( s^gh \) is a unit subsidy to green energy consumption. The functions \( u \) and \( e^h \) are increasing and concave in each argument.

To capture the capital-intensive nature of energy production, all energy types are produced using final goods. Production occurs competitively, and representative firms solve the problems

\[
\max_{x^j} (p_j^h + s^j_j) b_j (x^j) - x^j, \quad j = 1, \ldots, J
\]

and

\[
\max_{x^g} (p^x + s^g) g (x^g) - x^g,
\]

where \( b_j \) and \( g \) are increasing and concave functions measuring the domestic supply of energy, \( x^j \) and \( x^g \) are final good inputs, and \( s^j_j \) and \( s^g \) are subsidies for energy production.

The economy is endowed with a fixed labor supply, \( \bar{n} \), implying the equilibrium relationship:

\[
n = \bar{n}.
\]

Finally, we assume that the domestic economy is a net fossil fuel importer.

2.2. Objectives of the government

The government has three objectives. Firstly, it is concerned about the welfare of its citizens measured by \( u \).

Secondly, the government has a domestic emissions target:

\[
E = \sum_{j=1}^{J} (b_j^h + b_j^b), \tag{1}
\]

where the government is committed to reducing domestic emissions to \( E > 0 \).

Finally, to capture the national security cost associated with fossil fuel imports, the government’s objective function is

\[
U = u(x^h, e^h (b_1^h, \ldots, b_J^h), g^h) - \sum_{j=1}^{J} \eta_j \cdot (m_j^h - \bar{m}_j), \tag{2}
\]

where \( m_j^h \equiv b_j^h + b_j^b - b_j (\cdot) \) is the net fossil fuel import of type \( j \), and \( \eta_j \) measures the national security cost of this import above the exogenous level \( \bar{m}_j \).

The government wants to maximize (2) while achieving (1).

2.3. Implementing the optimal allocation

In the online appendix, we show how the government can implement the optimal allocation. The optimal policy presented below ignores terms-of-trade effects designed to manipulate international prices. This seems appropriate given that such manipulations violate international trade agreements. The resulting allocation is presumably close to the optimal one, as recent empirical evidence indicates that the terms-of-trade effects are small even for large economies (e.g., Amiti et al., 2020). See online appendix for an elaborate discussion.

The (near) optimal set of instruments is:

\[
\begin{align*}
\tau_j^{bx} &= \tau_j^{bh} = \frac{\eta_j}{\lambda} + \frac{\kappa}{\lambda} \quad \forall j \quad \tag{3} \\
\bar{s}_j^b &= \frac{\eta_j}{\lambda} \quad \forall j \quad \tag{4} \\
\bar{s}_g &= s^hy = s^gh = 0, \quad \tag{5}
\end{align*}
\]

where \( \kappa \) and \( \lambda \) are the shadow prices of domestic emissions and net imports, respectively.

If there is no national security concern, \( \eta_j = 0 \), we obtain the classic result: carbon emissions should be taxed uniformly across sectors, cf. (3).

However, when there is a national security concern associated with fossil-based input \( j \), \( \eta_j > 0 \), the carbon tax should be higher for emissions caused by that input, cf. (3). The consumption of fossil fuel \( j \) has a national security cost in addition to its environmental cost. This motivates a higher carbon tax compared to a fossil fuel \( j' \) without a national security concern, \( \eta_{j'} = 0 \).

Additionally, the national security concern motivates a production subsidy for domestic fossil energy production, cf. (4). The intuition is that there is a societal benefit in terms of less foreign energy dependence when domestic production increases.
There is no need for green energy subsidies, cf. (5). The carbon tax provides sufficient incentive to use and produce green energy. Meanwhile, the carbon taxes and subsidies for domestic fossil production are sufficient to ensure the right fossil-based energy mix.

3. Carbon capture and storage

We now consider a situation where production firms may abate emissions using the carbon capture and storage (CCS) technology from Kruse-Andersen and Sørensen (2021):

\[ a_j(x^a_j) \in (0, 1], \quad a'_j < 0, \quad a''_j > 0, \quad a_j(0) = 1, \]

\[ \lim_{x^a_j \to \infty} a_j(x^a_j) = 0, \]

where \((1 - a_j)\) is the share of emissions from fossil input \(j\) abated, and \(x^a_j\) is the final good input. The function captures that: (i) CCS is capital intensive, (ii) it becomes increasingly difficult to abate emissions, and (iii) it is impossible to capture all emissions.

Production emissions from fossil input \(j\) are now given by

\[ a_j(x^a_j) b^a_j \quad \text{and} \quad \text{production firms receive the unit CCS subsidy } s_j. \]

The following set of instruments implements the (near) optimal allocation:

\[ \tau_j^{bh} = \frac{\eta_j + \kappa}{\lambda} \quad \forall j \]

\[ \tau_j^{bx} = \frac{\eta_j}{\lambda} \frac{1}{a_j} + \frac{\kappa}{\lambda} \quad \forall j \]

\[ s_j^h = \frac{\eta_j}{\lambda} \quad \forall j \]

\[ s^h = s^b = s^{bh} = 0 \]

\[ s_j^b = -\frac{\eta_j}{\kappa} \quad \forall j. \]

Only (7) and (10) are new. CCS introduces a discrepancy between emissions and fuel consumption in the production sector. One emission unit from fuel \(j\) now results from \(1/a_j\) units of fuel consumption and thereby a \(1/a_j\) unit increase in net imports. Hence, the national security cost per unit of emission increases, resulting in a higher tax rate, cf. (7). However, the higher emission tax also increases the incentive to conduct CCS. The government corrects this through a negative CCS subsidy, cf. (10).

4. Concluding remarks

This study shows that national security concerns can motivate fuel-differentiated carbon taxation and subsidies for domestic fossil-based energy production. These policy implications contrast the typical climate policy recommendation of uniform carbon taxation.

Retrospectively, these results suggest that the EU should have placed a higher carbon price on natural gas and subsidized domestic natural gas extraction to limit its Russian energy dependency.

Infrastructure like pipelines is an important aspect of energy supply. As the model does not feature infrastructure investments, the equilibrium is best interpreted as a long-run equilibrium. Thus, the model shows what to do in times of peace and what to aim for in the long run, while it is less suited for short-run analysis.

A limitation of the analysis is the one-dimensionality of the foreign economy. National security costs associated with fossil fuel imports differ depending on the characteristics of the supplying country. However, the fossil fuel types used in the model developed here (the \(j\)s) could represent different fuels from different countries as long as they are not perfect substitutes. Although fuels of a specific type (e.g., natural gas) originating from different countries are perfect substitutes in the final burning process, they are inherently different further up the supply chain, for instance, due to transportation costs. This is why Spain mostly imports natural gas from Algeria, while Germany mostly relies on Russian gas. Importantly, the fossil fuel prices in the model only cover fuel purchases, while domestic transportation costs are hidden in the production function. Within this interpretation, the immediate implication is that fossil fuel consumption should be taxed differently depending on the country of origin, which seems to violate WTO rules. These issues are worth exploring further in future research.

Data availability

No data was used for the research described in the article.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2022.110923.

References


