Data Centers and Electricity Bills: Pecuniary Externality?[*]

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Abstract

The rapid proliferation of data centers across the United States has sparked concerns about their potential impact on electricity prices, which could consequently impose higher utility costs on residential households. This paper presents a simple framework to illustrate how increased electricity demand and resulting price hikes can lead to pecuniary externalities, ultimately reducing efficiency in the presence of market frictions. These frictions include borrowing constraints and the costs associated with relocating to different areas, which limit an ability of households to efficiently respond to changes in electricity prices. We examine potential policy interventions, considering both governmental measures and actions by utility companies and technology firms involved.

Keywords: Data Centers, Pecuniary Externalities, Financial Frictions, Moving Costs

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1 Introduction

The surge in artificial intelligence has fueled a rapid expansion of data centers, substantially increasing electricity demand and its prices in certain U.S. regions with high concentration of data centers.[1,2] The strain on aging grid infrastructure is often exacerbated, necessitating utility companies to upgrade transmission lines and stations. Consequently, utility companies pass these incurred costs onto residential consumers, impacting their bills.

The ensuing fundamental question is whether the impact on society, encompassing both residential households and data centers, is negative. According to the first welfare theorem, in a frictionless, complete market, changes in prices, such as those resulting from heightened demand within a segment of the economy, do not compromise efficiency. Therefore, in those cases, the construction of data centers and following increases in electricity prices would not be an important issue from efficiency perspective. In incomplete markets, however, such price changes can significantly affect societal welfare[3]

This paper presents a stylized three-period model that illustrates how increasing electricity demand and prices, spurred by the concentration of data centers, influence household welfare through *pecuniary externalities* when market frictions are present.[4] In this context, rising electricity prices negatively affect overall welfare. To account for the inefficiencies tied to pecuniary externalities, we incorporate two types of market imperfections: a collateral constraint and the expenses associated with relocating to alternative areas. In line with the literature, we assume that borrowers can only borrow up to a given fraction of the value of their assets (e.g., housing) under the collateral constraint.

In the benchmark case where the collateral constraint for residential users is not binding, they can take on additional loans to manage higher electricity costs when data centers raise their prices, effectively offsetting the increased bills. Thus, higher electricity prices due to increased demand from data centers do not hinder efficiency in this scenario.

[1] Some studies indicate that data centers may reduce average retail electricity prices by boosting baseline demand. This enables utility companies to distribute fixed costs over a broader user base, potentially lowering costs for all consumers. However, this conjecture is largely being rejected by the data. For this conjecture, see e.g., `https://www.ethree.com/wp-content/uploads/2025/12/RatepayerStudy.pdf` provided by PG&E.

[2] In regions with dense data center populations, including Northern Virginia, Illinois, and Ohio, residential utility bills have escalated more rapidly than the national average. Residents in areas like Maryland and Ohio are experiencing monthly increases ranging from \$16 to \$18. In the meantime, some utility companies, e.g., PJM interconnections and PG&E, have reported record profits in recent years.

[3] For fundamental works on this issue, see e.g., Geanakoplos and Polemarchakis (1985).

[4] For prominent recent papers on pecuniary externality, see e.g., Lorenzoni (2008), Jeanne and Korinek (2010), Dávila and Korinek (2017).

When the collateral constraint becomes binding, households reach their borrowing limits, making it impossible for them to obtain sufficient funds to achieve their preferred consumption levels during the period of surging electricity prices. Lower consumption, in turn, reduces asset values (e.g., house prices decline as residents allocate more income to higher electricity bills, reducing consumption).[5] This impact on asset prices tightens the collateral constraint, further reducing consumption and generating a negative feedback loop between asset values and consumption. As a result, overall efficiency is diminished.

Following widespread public criticism regarding the construction of data centers, companies like Microsoft have pledged to pay higher, premium electricity rates for its facilities. This move is aimed at ensuring that energy costs do not pass through to local communities and residents.[6] Those companies have additionally pledged to fund essential grid upgrades and prioritize hiring local individuals for its data centers, even if these facilities require only a minimal workforce.[7] Our analysis indicates that these policies are likely to substantially mitigate the scope of pecuniary externalities. In particular, the strategy of employing local workers at data centers acts as a means of redistributing resources to households during periods of rising electricity costs, thereby easing financial friction and minimizing the effects of the externalities.

The primary driver of pecuniary externalities in our model lies in the fact that individual agents, including data centers, fail to account for how their electricity demand affect prices of utilities and assets (e.g., housing) in equilibrium, which, in turn, impact their borrowing capacities, consumption levels, and overall welfare. This feature creates an *ex-ante* opportunity for efficiency improvements. In the context of a constrained-efficient equilibrium, the social planner implements a reduction in borrowing prior to the construction of data centers, ensuring that residential users have greater cash availability. We show that the constrained-efficient equilibrium can be easily decentralized by a tax on borrowing, which is a function of a few sufficient statistics.

Finally, if households had the ability to move to a different city or neighborhood without incurring any costs, they could effectively avoid the impact of rising electricity prices and escape the binding collateral constraint caused by the establishment of new data centers in their current location. However, our analysis indicates that significant moving expenses often serve as a barrier, discouraging relocation and leaving households exposed to pecu-

[5] In our model, this happens as the effective discount rate of the household rises.

[6] For example, https://www.cnn.com/2026/01/13/tech/microsoft-ai-data-centers-electricity-bills-plan.

[7] See https://www.ft.com/content/3f392c9b-c07d-42f5-b000-0a7347ad1ec0.

niary externalities from increasing electricity costs in their original area. It is because large relocation costs increase the borrowing needs of households, potentially exposing them to more severe financial constraints in their new location without data centers.

2 The Model

This section introduces a tractable model with three time periods $t = 0, 1, 2$ for illustrating the key points about pecuniary externalities driven by an electricity demand shock.[8]

There is a continuum of measure-one identical households with the following preference:[9]

$$u(c_o) + u(c_1) + \theta v(T_1) + c_2, \tag{1}$$

where c_0, c_1, and c_2 are consumption levels at $t = 0$, 1, and 2, respectively. In addition to regular consumption, a household consumes electricity at $t = 1$, whose demand is denoted by T_1. $u(\cdot)$ is the consumption utility of households at $t = 0, 1$, satisfying usual conditions: $u'(\cdot) > 0$, $u''(\cdot) < 0$, and $\lim_{s \to 0} u'(s) = \infty$.

θ in (1) is the electricity demand parameter. We assume that the value of θ is realized at $t = 1$. θ is the only *aggregate* shock in the model, e.g., if a new data center is constructed at $t = 1$ near a neighborhood, raising demand for electricity, it is captured by θ being high for the representative household.[10] At $t = 0$, each household believes that $\theta \sim F_\theta(\cdot)$, where $F_\theta(\cdot)$ is the probability distribution of θ from $t = 0$'s perspective. Throughout this section, we assume that the construction of data centers corresponds to high θ realization at $t = 1$.

Electricity supply is fixed at T, so in equilibrium, it must be that $T_1 = T$.[11] Finally, each household receives endowment e at $t = 1$, and y at $t = 2$, both of which are certain.

There is a storage technology with zero interest for one-period borrowing and lending

[8] Our model builds on the literature on pecuniary externality, e.g., Lorenzoni (2008), Jeanne and Korinek (2010), and Dávila and Korinek (2017). For aggregate demand externality issues, see e.g., Farhi and Werning (2016).

[9] Due to the representative agent setting, we do not distinguish between individual variables and aggregate variables.

[10] This is obviously a simplistic modeling device: data centers built by technology companies and ordinary electricity users are different in the real world. We choose this way of modeling due to tractability advantages of the representative household setting, while delivering relevant insights about pecuniary externalities.

[11] Note that utility companies might accommodate extra electricity demand from data centers by investing in additional grid infrastructure and transmission lines, which usually takes time. We abstract from a potential supply response in the short run for tractability purposes.

available to households: if a household borrows d_1 at $t = 0$ and d_2 at $t = 1$, her intertemporal budget is given by

$$\begin{aligned} c_0 &= d_1 \\ c_1 &= e - d_1 + d_2 - p_T T_1 \\ c_2 &= y - d_2 + p_T T \end{aligned} \tag{2}$$

where p_T is the price of electricity at $t = 1$, which is to be determined in equilibrium. Note that in (2), we assume that the total revenue of utilities, $p_T T$, is lump-sum rebated to each households at $t = 2$.[12] This assumption essentially ensures that resources are utilized without waste in equilibrium. In practical terms, this could relate to the long-term benefits that data centers may contribute to neighborhoods where they are established. We will later discuss this assumption in depth.

Financial friction At $t = 1$, households can trade their 'claims' to $t = 2$ endowment y in a secondary market, in which the asset price, q_1, is given by[13]

$$q_1 = \frac{y}{u'(c_1)}. \tag{3}$$

As households are identical ex-ante and ex-post, no trade occurs in the financial market: still q_1 is an equilibrium variable. Note that in (3), lower $t = 1$ consumption leads to lower q_1, as households become effectively less patient and thus discount their $t = 2$ endowment more.

Households face the following collateral constraint for borrowing at $t = 1$:

$$d_2 \leq \kappa q_1 \tag{4}$$

where $\kappa \leq 1$. Each household takes p_T and q_1 as given for their consumption and borrowing decisions, i.e., markets for goods and assets are competitive.

[12] Note in (2) that electricity demand T_1 appears in $t = 1$ budget, and the total revenue of utility companies, $p_T T$, is redistributed back to households at $t = 2$. In equilibrium, $p_T T_1 = p_T T$.

[13] Equation (3) is directly from household preference (1).

The first-best allocation The first-best consumption path (i.e., without financial friction (4)) would be

$$c_0 = c_1 = c^* \tag{5}$$

where $u'(c^*) = 1$. With $T_1 = T$ in equilibrium, the electricity price at $t = 1$ is given by

$$p_T = \frac{\theta v'(T)}{u'(c^*)} = \theta v'(T), \tag{6}$$

where higher θ caused by the construction of data centers raises electricity price p_T in this benchmark. However, it does not affect total welfare, which is given by $2u(c^*)+e+y-2c^*$. It is due to the first welfare theorem: pecuniary changes do not affect efficiency unless there is a friction, as each household optimally responds to those price changes.

In this case, each household optimally chooses

$$\begin{aligned} d_1 &= c^* \\ d_2 &= 2c^* - e + \underbrace{\theta v'(T)}_{=p_T} T \\ c_2 &= e + y - 2c^*. \end{aligned}$$

When higher θ is realized, households can borrow more at $t = 1$, i.e., higher d_2, to finance higher electricity bills $p_T T$. This additional borrowing is possible at $t = 1$ as eventually at $t = 2$, higher revenues of the utility companies are rebated to households. In this first-best scenario, this behavioral response of households insulates changes in electricity price p_T to affect their welfare.

As we show, however, once we take the collateral constraint (4) into account, this result does not generically hold anymore.

2.1 Decentralized Equilibrium

2.1.1 Optimization at $t = 1$

We now solve the individual optimization by backward induction, when the collateral constraint (4) might bind at $t = 1$.

At $t = 1$, the representative household's state variables are (m_1, θ) where $m_1 \equiv e - d_1$ is her cash amount in hand. Each household solves the following intertemporal optimization for $t = 1$ and $t = 2$:[14]

$$\begin{aligned} V_{1f}(m_1;\theta) &\equiv \max_{T_1,d_2} \left[u(c_1) + \theta v(T_1) + c_2\right] \\ &= \max_{T_1,d_2} \left[u\left(\underbrace{m_1 + d_2 - p_T T_1}_{=c_1}\right) + \theta v(T_1) + \underbrace{y - d_2 + p_T T}_{=c_2}\right] \end{aligned} \tag{7}$$

subject to

$$d_2 \leq \kappa q_1, \tag{8}$$

where $V_{1f}(m_1;\theta)$ is defined as the value function at $t = 1$ given (m_1, θ). Each household takes p_T and q_1 as given, both of which are determined in equilibrium.

No binding When the collateral constraint (8) is not binding at optimum, the solution of (7) coincides with the first-best allocation: $c_1 = c^*$, with electricity price $p_T = \theta v'(T)$ and asset price q_1 given by

$$q_1 = y, \tag{9}$$

which is consistent with equations (5) and (6). In this case, d_2 that solves (7) is given by

$$d_2 = c^* + \theta v'(T)T - \underbrace{m_1}_{=e-d_1}. \tag{10}$$

As the last step, we need to ensure that equations (9) and (10) satisfy the original constraint (8), i.e.,

$$d_2 = c^* + \theta v'(T)T - (e - d_1) \leq \kappa y$$

which is

$$\theta \leq \underbrace{\frac{e - d_1 + \kappa y - c^*}{v'(T)T}}_{\equiv \theta^*(d_1)}. \tag{11}$$

[14]Note that θ is realized at $t = 1$, so households choose their consumption and borrowing decisions based on θ in solving (7).

Therefore, when the electricity demand parameter θ is realized to be lower than $\theta^*(d_1)$ defined in (11), households at $t = 1$ borrow according to (10) to ensure $c_1 = c^*$ and $T_1 = T$, insulating their welfare from a change in electricity price p_T. Note that the threshold $\theta^*(d_1)$ is decreasing in d_1: higher d_1 at $t = 0$ reduces cash in hand at $t = 1$, which in turn increases the demand for borrowing given any θ realizations. It raises the likelihood that the collateral constraint (8) binds at optimum.

When $\theta > \theta^*(d_1)$ at $t = 1$, we move to the next binding case.

Binding Note that the collateral constraint given by (8) is more likely to bind under higher θ realizations at $t = 1$. Higher θ leads to higher electricity price p_T at $t = 1$, reducing c_1 given m_1 and d_2. Households then want to increase borrowing d_2 to make c_1 closer to c^*, which makes it more likely for the constraint (8) to bind. If (8) binds, they cannot raise c_1 to c^*, creating market incompleteness and a pecuniary externality caused by higher electricity demand. Inequality (11) implies that when θ is higher than $\theta^*(d_1)$, the economy enters the second regime with binding (8).

c_1 decreasing from c^* due to the binding constraint reduces asset price q_1 from its first-best level y. This effect makes the collateral constraint (8) tighter, leading to even lower c_1 and creating a self-reinforcing perpetual cycle between c_1 and q_1 until the system reaches a new equilibrium.

More specifically, when constraint (8) is binding, the equilibrium is represented by

$$p_T = \frac{\theta v'(T)}{u'(c_1)}, \quad q_1 = \frac{y}{u'(c_1)}, \quad d_2 = \kappa \underbrace{\frac{y}{u'(c_1)}}_{=q_1}$$

leading to

$$c_1 = e - d_1 + \frac{\kappa y - \theta v'(T)T}{u'(c_1)}, \tag{12}$$

where equilibrium c_1 is a fixed-point solution of equation (12). We denote the solution of equation (12) by $c_{1f}(e-d_1, \theta)$. By construction, $c_{1f}(e-d_1, \theta) < c^*$, creating an inefficiency with a welfare loss.

Assumption 1 (Existence and Uniqueness of Solution)**.** *We assume that*

$$\kappa y \frac{d}{dc}\left(\frac{1}{u'(c)}\right) < 1$$

for any positive c.

Assumption (1) guarantees the existence and uniqueness of c_1 that satisfies (12). Defining a new function

$$f(c_1;\theta) = e - d_1 + \frac{\kappa y - \theta v'(T)T}{u'(c_1)},$$

the solution of (12) when $\theta = \theta_1$ can be represented by Point A in the following Figure 1:

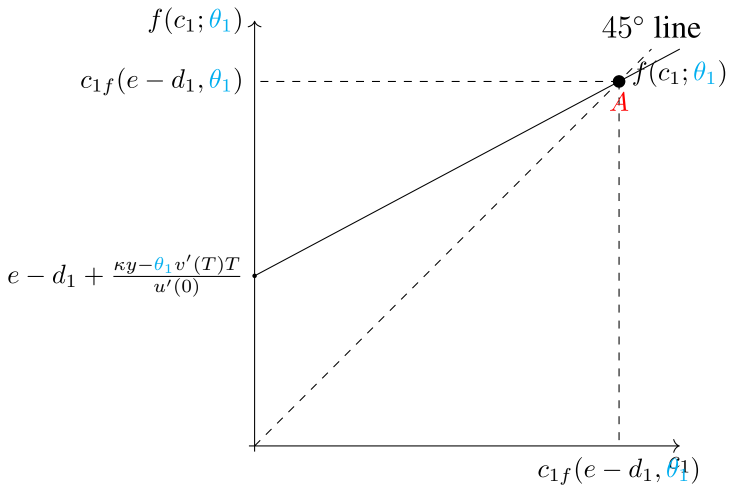

Figure 1: Equilibrium Consumption with $\theta = \theta_1$

Higher θ realizations lead to lower consumption c_1 at $t = 1$ when the collateral constraint (8) binds, i.e., $c_{1f}(e - d_1, \theta)$ is decreasing in θ. This can be seen in Figure 2, which compares $\theta = \theta_1$ (Point A) with $\theta = \theta_2 > \theta_1$ (Point B): when households are borrowing-constrained, higher electricity price due to data centers in their neighborhood force them to reduce more of their regular consumption, causing a larger welfare distortion.

Therefore, higher θ, leading to higher electricity price p_T at $t = 1$, creates an *ex-post* welfare loss compared with the first-best scenario. The logic behind this key result can be summarized as follows.

Step 1 Each household, in response to higher realized θ in period 1, raises demand for electricity, which leads to higher p_T in equilibrium. Their electricity bills rise in response, reducing their regular consumption given d_2.

Step 2 In the presence of the borrowing constraint (i.e., incomplete market), it reduces asset price q_1 (e.g., house prices decrease as residents pay higher electricity bills), tightening the collateral constraint and further reducing c_1. Households welfare falls.

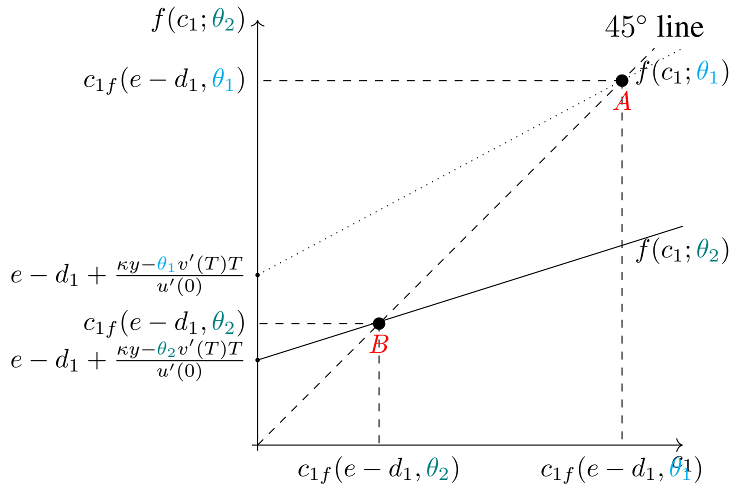

Figure 2: Equilibrium Consumption: $\theta = \theta_1$ versus $\theta = \theta_2$ with $\theta_2 > \theta_1$

Step 3 This is an example of *pecuniary externanlity*: each household does not internalize this effect of

$$\boxed{\text{higher } \theta \longrightarrow \text{higher } p_T \longrightarrow \text{lower } q_1}$$

which in turn affects their borrowing limit, consumption, and welfare.[15]

In general, efficient financial markets enable households to shield their welfare from price fluctuations (in our case, rising electricity prices from higher realized θ values). However, when financial market frictions arise, they create pecuniary externalities that impact welfare and necessitate government intervention. This issue is discussed further in Section 2.2.

Revenue of electricity companies Fundamentally, the above result is related to our model setting that the utility companies' total revenue $p_T T$ is lump-sum rebated to households at $t = 2$, not $t = 1$.

To see this, assume that $\theta > \theta^*(d_1)$. In this case, households pay higher electricity bills, hitting the borrowing constraint (8). The revenue of electricity companies, $p_T T$, rises as p_T rises under higher realized θ. If $p_T T$ is lump-sum transferred to households at $t = 1$, then no pecuniary externality arises from the collateral constraint (8) as households do not need to raise borrowing in response to higher θ realizations. In specific, the budget dynamics of

[15] Dávila and Korinek (2017) characterize two types of pecuniary externalities due to financial constraints: distributive externalities from incomplete markets and collateral externalities from price-dependent financial constraints. Our pecuniary externality corresponds to the latter case.

the household in this case will be given by

$$c_0 = d_1$$
$$c_1 = e - d_1 + d_2 - p_T T_1 + p_T T \tag{13}$$
$$c_2 = y - d_2,$$

in which case households can always achieve their first-best allocation: $c_0 = c_1 = c^*$ with $c_2 = e + y - 2c^*$. When p_T is realized to be high, households incur higher utility costs but simultaneously enjoy increased transfer at $t = 1$. This dynamic removes the necessity for additional borrowing, effectively reducing the likelihood of reaching the borrowing limit.[16]

A partial rebate of $p_T T$ at $t = 1$ is sufficient to avoid reaching the borrowing limit set by (8). Let $\alpha(\theta)$ represent the portion of electricity revenue $p_T T$ that is distributed as a lump-sum rebate to households at $t = 1$.[17] The minimum level of $\alpha(\theta)$ required for households to no longer be restricted by the collateral constraint (thereby attaining c^*) is expressed as

$$\alpha(\theta) = 1 - \frac{e - d_1 + \kappa y - c^*}{\theta v'(T)T} > 0$$

when $\theta > \theta^*(d_1)$. In this case, households achieve the first best with $c_1 = c^*$.

Overall, the partial revenue rebate at $t = 1$ helps reduce the extent of financial friction at $t = 1$, addressing pecuniary distortions caused by increases in electricity demand parameter θ. It is also important to note that $\alpha(\theta)$ is an increasing function of θ, meaning that greater pecuniary impacts (i.e., higher θ values) necessitate a larger redistribution of revenues to households at $t = 1$.

Real world examples In response to multiple backlashes from the public against the construction of data centers, Microsoft, for example, has committed to paying higher, premium

[16]The fundamental role of the financial market in our model is to allow households to move consumption across periods. The rebate of electricity companies' revenue $p_T T$ at $t = 1$ effectively obviates the importance of frictions in the financial market, as households do not anymore need to adjust their borrowing in response to θ changes.

[17]In this case, the budget dynamics of the household will be given by

$$c_0 = d_1$$
$$c_1 = e - d_1 + d_2 - p_T T_1 + \alpha(\theta) p_T T$$
$$c_2 = y - d_2 + (1 - \alpha(\theta)) p_T T.$$

rates for electricity for its data centers to prevent passing energy costs to local communities and residents.[18] From the perspective of our framework, this approach will increase households' resources at $t = 1$, preventing them from reaching the borrowing constraint (8) and enabling them to achieve the optimal consumption level c^*.

The company has also committed to paying for required grid upgrades and hiring local people for its data centers even if those data facilities do not need many employees.[19] These policies are expected to significantly lessen the extent of pecuniary externalities. Notably, the policy focused on hiring local workers for its data centers will function as a resource transfer back to households at time $t = 1$, helping to alleviate financial constraints and reduce the impact of pecuniary externalities.

2.1.2 Optimization at $t = 0$

Given the budget constraint (2) and $t = 1$ value function $V_{1f}(m_1; \theta)$ defined in (7), at $t = 0$, households choose optimal d_1 that satisfies:

$$u'(c_0) = \mathbb{E}_0 V'_{1f}(m_1; \theta) = \mathbb{E}_0 u'(c_1)$$

where from (7) we obtain $V'_{1f}(m_1; \theta) = u'(c_1)$.

Note that $u'(c_0) = u'(d_1)$ and

$$u'(c_1) = \begin{cases} u'(c^*), & \text{if } \theta \leq \theta^*(d_1) \\ u'(c_{1f}(e - d_1, \theta)), & \text{if } \theta > \theta^*(d_1). \end{cases} \tag{14}$$

from the $t = 1$ optimization result of Section 2.1.1. Therefore, optimal borrowing at $t = 0$, denoted d^*_{1p}, is chosen to satisfy:

$$\underbrace{u'(d^*_{1p})}_{\downarrow \text{ in } d^*_{1p}} = u'(c^*) + \underbrace{\left[u'(c_{1f}(e - d^*_{1p}, \theta)) - u'(c^*)\right] \left(1 - F_\theta(\theta^*(d^*_{1p}))\right)}_{\uparrow \text{ in } d^*_{1p}}, \tag{15}$$

where the existence of solution d^*_{1p} is guaranteed since the left-hand side of (15) is decreasing in d^*_{1p} while the right-hand side is increasing in d^*_{1p}.

[18] For example, https://www.cnn.com/2026/01/13/tech/microsoft-ai-data-centers-electricity-bills-plan.

[19] See https://www.ft.com/content/3f392c9b-c07d-42f5-b000-0a7347ad1ec0.

2.2 Constrained Efficiency

As discussed in Step 3, pecuniary externality arises in our model since each household does not internalize the effect of the electricity demand parameter θ (and p_T) on equilibrium asset price q_1, which in turn affects their borrowing limit, consumption, and welfare.

Following the literature, e.g., Lorenzoni (2008), Jeanne and Korinek (2010), and Dávila and Korinek (2016), we now consider the constrained efficiency allocation:

- The social planner acknowledges the collateral constraint (8) at $t = 1$, like the private agents (i.e., households) in the decentralized equilibrium.

- However, the social planner internalizes how choices of d_1 at $t = 0$ affect the electricity price p_T and asset price q_1 at $t = 1$. In contrast, in the decentralized equilibrium of Section 2.1.1 and Section 2.1.2, individual household takes q_1 and p_T as given.

Given that higher d_1 (i.e., lower m_1 in optimization (7)) lowers $\theta^*(d_1)$ in (11) and makes it more likely that the collateral constraint (8) binds,[20] the social planner makes households borrow less at $t = 0$ (ex-ante) to mitigate the pecuniary externality stemming from financial friction.[21]

Optimization at $t = 1$ The social planner's optimization at $t = 1$ is the same as (7) for the decentralized equilibrium. The state variables are still (m_1, θ), where $m_1 \equiv e - d_1$ is the cash amount in hand in $t = 1$:[22]

$$
\begin{aligned}
V_{1s}(m_1;\theta) &\equiv \max_{T_1,d_2} \left[u(c_1) + \theta v(T_1) + c_2\right] \\
&= \max_{T_1,d_2} \left[u\left(\underbrace{m_1 + d_2 - p_T T_1}_{=c_1} \right) + \theta v(T_1) + \underbrace{y + p_T T - d_2}_{=c_2} \right]
\end{aligned}
\tag{16}
$$

subject to

$$
d_2 \leq \kappa q_1(m_1, \theta). \tag{17}
$$

where the key difference from (7) is that now, the constraint (17) accounts for the effect of m_1 on the equilibrium asset price q_1. Since (m_1, θ) (and q_1 as well) are given at $t = 1$, this

[20] Note also that consumption in the binding case, $c_{1f}(e - d_1, \theta)$, is decreasing in d_1.

[21] Therefore, this section focuses on ex-ante (constrained) efficiency, while Section 2.1.1 discusses ex-post inefficiency caused by pecuniary externality.

[22] We define $V_{1s}(m_1;\theta)$ as the value function at $t = 1$ given (m_1, θ) from social planner's perspective.

feature does not affect the optimal solution for $t = 1$ optimization: the optimal consumption c_1 that solves (16) when the constraint (17) binds is still $c_{1f}(e - d_1, \theta)$.[23]

However, the fact that the social planner accounts for the effect of m_1 (and d_1) (which are chosen at $t = 0$) on q_1 (which is a $t = 1$ aggregate variable) changes how she chooses optimal borrowing d_1 at $t = 0$.

Optimization at $t = 0$ Denoting λ_{1s} as the Lagrange multiplier to (17) and $c_{1f}(e - d_1, \theta)$ as the solution of (16), which is the same as for the decentralized solution, we differentiate the value function $V_{1s}(m_1; \theta)$ with respect to m_1 and obtain

$$V'_{1s}(m_1; \theta) = u'(c_1) + \underbrace{\lambda_{1s} \cdot \kappa \frac{\partial}{\partial m_1} q_1(m_1, \theta)}_{\text{Additional term}}. \tag{18}$$

Note that (18) is different from the decentralized case, i,e., (7), where $V'_{1f}(m_1; \theta) = u'(c_1)$. In the competitive equilibrium, each household takes q_1 as given while q_1 is jointly determined by consumption-borrowing choices of all households. In contrast, the social planner accounts for the fact that higher m_1 (lower d_1) relaxes the collateral constraint (8) at $t = 1$ by raising q_1 in equilibrium. This gives an additional benefit for the social planner of raising cash on hand at $t = 1$.

When the constraint (17) is binding, we have $u'(c_1) = 1 + \lambda_{1s}$, from which we obtain[24]

$$\lambda_{1s} = u'(c_{1f}(e - d_1, \theta)) - 1 > 0. \tag{19}$$

Since

$$q_1(m, \theta) = q_1(e - d_1, \theta) = \frac{y}{u'(c_{1f}(e - d_1, \theta))},$$

we have

$$\frac{\partial}{\partial m} q_1(m, \theta) = -\frac{\partial}{\partial d_1} \left(\frac{y}{u'(c_{1f}(e - d_1, \theta))} \right).$$

[23]When constraint (17) does not bind, e.g., realized θ is low enough, the solution of (16) is $c_1 = c^*$, which is the same as in the decentralized equilibrium.

[24]Since $c_{1f}(e - d_1, \theta) < c^*$ and $u'(c^*) = 1$, $\lambda_{1s} > 0$ in (19).

Therefore, (18) becomes

$$V_{1s}'(m_1;\theta) = u'(c_{1f}(e-d_1,\theta)) \underbrace{-\lambda_{1s}\kappa\frac{\partial}{\partial d_1}\left(\frac{y}{u'(c_{1f}(e-d_1,\theta))}\right)}_{>0}. \tag{20}$$

Note from (19) and (20) that $V_{1s}'(m_s;\theta) > u'(c_1)$: the social planner prefers to borrow less at $t=0$ to mitigate the effect of the binding constraint caused by high realized θ at $t=1$.

From (20), optimal d_1 in the constrained-efficient equilibrium must satisfy

$$\underbrace{u'(d_{1s}^*)}_{\downarrow \text{ in } d_{1s}^*} = u'(c^*) + \left[V_{1s}'(e-d_{1s}^*,\theta) - u'(c^*)\right]\left(1 - F_\theta(\theta^*(d_{1s}^*))\right), \tag{21}$$

where optimal d_1 chosen by the social planner is denoted d_{1s}^*, and

$$V_{1s}'(e-d_{1s}^*;\theta) = u'(c_{1f}(e-d_{1s}^*,\theta)) \underbrace{-\lambda_{1s}^*\kappa\frac{\partial}{\partial d_1}\left(\frac{y}{u'(c_{1f}(e-d_{1s}^*,\theta))}\right)}_{>0},$$

where the endogenous Lagrange multiplier λ_{1s}^* is given by

$$\lambda_{1s}^* = u'(c_{1f}(e-d_{1s}^*,\theta)) - 1 > 0. \tag{22}$$

Macroprudential policy Returning to the original case of the construction of data centers, recall that the main source for pecuniary externalities in our model is that households are financially constrained: they cannot borrow *ex-post* enough to offset the effect of rising electricity prices on consumption and welfare.

Since *ex-post* borrowing is constrained, the government can introduce a tax on borrowing, a special kind of macroprudential policies, to affect *ex-ante* borrowing, i.e., to reduce d_1 and achieve the constrained-efficient solution (21).

With τ on borrowing at $t=0$, we can make the decentralized equilibrium coincide with the constrained-efficient allocation. The consumption Euler equation in the presence of tax τ is given by

$$u'(c_0) = (1+\tau)\mathbb{E}_0 u'(c_1). \tag{23}$$

To synchronize (23) with the constrained-efficient solution (21), optimal τ can be set at

$$\tau = \frac{\mathbb{E}_0 \left(-\lambda_{1s}^* \kappa \frac{\partial}{\partial d_1} \left(\frac{y}{u'(c_{1f}(e-d_{1s}^*, \theta))} \right) \right)}{u'(c^*) + \left[V_{1s}'(e - d_{1s}^*, \theta) - u'(c^*) \right] (1 - F_\theta(\theta^*(d_{1s}^*)))} > 0. \tag{24}$$

where λ_{1s}^* is given in (22). Note that the optimal macroprudential tax τ in (24) is a function of a few key sufficient statistics, in a similar fashion to Dávila and Korinek (2017).

2.3 Movement to a Different Location

If households could relocate to a different city or neighborhood without incurring any costs, they would be able to sidestep the burden of higher electricity prices and avoid the binding borrowing constraint due to new data centers being established in their current city. However, substantial moving expenses can act as a deterrent, preventing relocation and leaving households vulnerable to pecuniary externalities caused by rising electricity prices in their original area.

This section presents a stylized model variant illustrating this point. At $t = 1$, imagine that an 'atomic' household has θ_B as her electricity demand parameter while the entire city (i.e., the rest of households) has θ which is higher than θ_B.[25] We also assume the electricity supply T is a minimum subsistence level of electricity consumption, i.e., $T_1 \geq T$.[26] Finally, we assume $\theta > \theta^*(d_1)$ in the current city, i.e., all city residents are financially constrained by the constraint (8), including the atomic household. Throughout the section, we focus on *ex-post* (i.e., $t = 1$) problem, taking $t = 0$ borrowing d_1 as given.

In the original city at $t = 1$, the atomic household solves

$$\begin{aligned} V_{1f}(m_1; \theta_B) &\equiv \max_{T_1, d_2} \left[u(c_1) + \theta_B v(T_1) + c_2 \right] \\ &= \max_{T_1, d_2} \left[u \left(\underbrace{m_1 + d_2 - p_T T_1}_{=c_1} \right) + \theta_B v(T_1) + \underbrace{y - d_2 + p_T T}_{=c_2} \right] \end{aligned} \tag{25}$$

[25] This can be a case in which it is announced that a new data center has been built in my city or neighborhood, while my electricity needs stay the same.

[26] Thus, even if the atomic household with electricity demand parameter θ_B wants to reduce her electricity consumption T_1 from T when the city's higher demand for electricity pushes its price p_T up, she cannot. This assumption is introduced for tractability purposes only.

subject to

$$d_2 \leq \kappa q_1 \text{ and } T_1 \geq T, \tag{26}$$

where

$$q_1 = \frac{y}{u'(c_{1f}(e - d_1, \theta))}, \tag{27}$$

and

$$p_T = \frac{\theta v'(T)}{u'(c_{1f}(e - d_1, \theta))}. \tag{28}$$

Note in (27) and (28) that asset price q_1 and electricity price p_T depend on consumption of other households with electricity demand parameter θ, which is given by $c_{1f}(e - d_1, \theta)$.

The optimal consumption and electricity demand of the atomic household solving (25) is given by $T_1 = T$ and

$$c_1 = c_{1f}(e - d_1, \theta),$$

which is the same as other households. The logic behind this is simple: the atomic household wants to reduce electricity demand T_1 from T, but cannot. Therefore, her consumption becomes equal to the consumption of others.

This solution is *ex-post* inefficient, since the atomic household is financially constrained (i.e., (26)) and

$$p_T = \theta \frac{v'(T)}{u'(c_{1f}(e - d_1, \theta))} > \underbrace{\theta_B \frac{v'(T)}{u'(c_{1f}(e - d_1, \theta))}}_{\substack{\text{Marginal rate of substitution (MRS)} \\ \text{of the atomic household}}},$$

implying that the equilibrium electricity price is now above the marginal rate of substitution of the atomic household between electricity demand and consumption, due to the minimal electricity constraint $T_1 \geq T$. The collateral constraint and this wedge in the marginal rate of substitution jointly generate distortions on the atomic household from pecuniary changes in electricity.

Consider a scenario where there exists another location, which is ex-ante identical to the original city but has θ_B as its electricity demand parameter at $t = 1$. If feasible, the atomic household with θ_B would prefer to relocate to the new city. It is because $\theta_B < \theta$ signifies both a reduced probability and a less severe effect of the binding collateral constraint (26). Additionally, in this new city, the electricity price aligns with the household's marginal rate of substitution.

However, in order to move, the atomic household is required to pay $M(\theta; \theta_B)$ as *moving costs* at $t = 1$, which are reimbursed at $t = 2$.[27]

Note that because the two cities are ex-ante identical, borrowing at $t = 0$, d_1, is identical across the two locations as well. We consider the following two cases.

Case 1 $\theta_B < \theta^*(d_1)$, i.e., residents in the new city are not financially constrained, achieving full ex-post efficiency with $c_1 = c^*$ at $t = 1$.

Case 2 $\theta_B > \theta^*(d_1)$, i.e., residents in the new city are financially constrained with consumption given by $c_1 = c_{1f}(e - d_1, \theta_B)$ at $t = 1$.

Case of $\theta_B < \theta^*(d_1)$ In this case, all residents in the new city achieve full efficiency with $c_1 = c^*$, meaning

$$p_T^B = \theta_B v'(T), \;\; q_1^B = y \tag{29}$$

in the new city with superscript B.

If the atomic household moves to the new city by paying $M(\theta; \theta_B)$, her consumption at $t = 1$ given borrowing d_2 will be:

$$c_1 = e - d_1 - M(\theta; \theta_B) + d_2 - \underbrace{\theta_B v'(T)}_{=p_T^B} T_1.$$

We assume that financial friction for the atomic household after relocating to the new city is governed by the new asset price q_1^B in (29), i.e., $d_2 \leq \kappa q_1^B = \kappa y$. If

$$M(\theta; \theta_B) < \underbrace{\kappa y - [c^* + \theta_B v'(T) T - (e - d_1)]}_{\equiv M^*(\theta_B) > 0} \tag{30}$$

then the atomic household moves to the new city, achieving full efficiency with $c_1 = c^*$ and $T_1 = T$ there. This can be summarized as follows:

[27] For example, moving costs include differences in housing costs across the two cities, costs of decorating new houses and other physical investments in the new city, and so on, which eventually benefit her one period later in the case of relocating.

Proposition 1. *With $\theta_B < \theta^*(d_1)$, a small moving cost, satisfying*

$$M(\theta; \theta_B) < M^*(\theta_B),$$

leads to no efficiency loss from the pecuniary externality. In this case, the atomic household moves to the new city and enjoys full efficiency with $c_1 = c^*$. $M^*(\theta_B)$ is defined in (30).

On the other hand, if

$$M(\theta; \theta_B) > \underbrace{\kappa y - [c^* + \theta_B v'(T)T - (e - d_1)]}_{\equiv M^*(\theta_B) > 0}, \tag{31}$$

the atomic household, when she relocates, becomes financially constrained in the new city. In this case, she optimally chooses $d_2^B = \kappa y$ and

$$c_1^B = e - d_1 - M(\theta; \theta_B) - \theta_B v'(T)T + \kappa y < c^*.[28] \tag{32}$$

She compares c_1^B in (32) with her current consumption in the old city, which is $c_{1f}(e - d_1, \theta)$. If

$$c_{1f}(e - d_1, \theta) > c_1^B = e - d_1 - M(\theta; \theta_B) - \theta_B v'(T)T + \kappa y,$$

which can be rewritten as

$$M(\theta; \theta_B) > \kappa y - \left[c_{1f}(e - d_1, \theta) + \theta_B v'(T)T - (e - d_1)\right], \tag{33}$$

the atomic household stays in the old city, enduring inefficiency stemming from pecuniary changes caused by the construction of data centers. Note that (33) implies (31) as $c_{1f}(e - d_1, \theta) < c^*$.

From (31) and (33) and defining

$$\tilde{M}(\theta; \theta_B) \equiv \kappa y - \left[c_{1f}(e - d_1, \theta) + \theta_B v'(T)T - (e - d_1)\right],$$

which is increasing in θ,[29] we obtain the following result:

Proposition 2. *With $\theta_B < \theta^*(d_1)$, a large moving cost, satisfying*

$$M(\theta; \theta_B) > \tilde{M}(\theta; \theta_B),$$

[29] Note that $c_{1f}(e - d_1, \theta) < c^*$ implies $\tilde{M}(\theta; \theta_B) > M^*(\theta_B)$.

leads to pecuniary externalities and efficiency losses as the atomic households do not relocate to the new city. A medium-sized moving costs, satisfying

$$M^*(\theta_B) < M(\theta; \theta_B) < \tilde{M}(\theta; \theta_B),$$

induces the atomic household to move to the new city and mitigates the degree of pecuniary externalities generated by data centers. Still, she is financially constrained in the new city due to the moving cost $M(\theta; \theta_B)$.

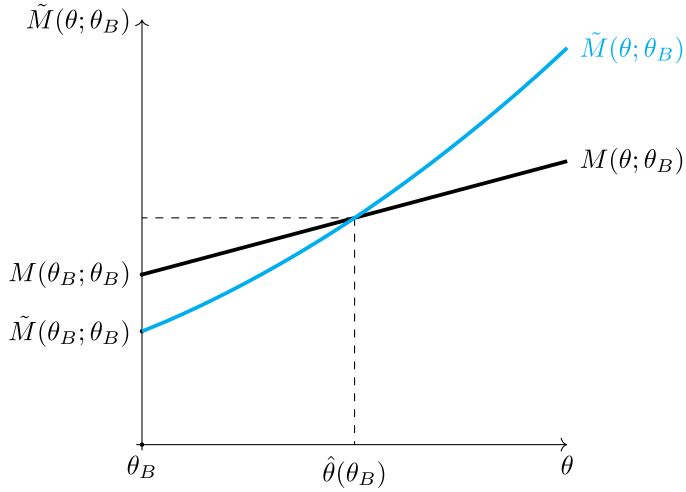

Figure 3: Realistic Case: $M(\theta; \theta_B)$ and $\tilde{M}(\theta; \theta_B)$

In Figure 3's case, the atomic household moves only if $\theta > \hat{\theta}(\theta_B)$, i.e., the price impact is too strong. Still, she cannot achieve the efficient consumption level in the new city. Here, the demand parameter threshold $\hat{\theta}(\theta_B)$ is defined by

$$M\left(\hat{\theta}(\theta_B), \theta_B\right) = \tilde{M}\left(\hat{\theta}(\theta_B), \theta_B\right).$$

Case of $\theta_B > \theta^*(d_1)$ In this case, all residents in the new city are borrowing-constrained with $c_1 = c_{1f}(e - d_1, \theta_B)$, meaning that electricity price p_T^B and asset price q_1^B in equilibrium are given by

$$p_T^B = \frac{\theta_B v'(T)}{u'(c_{1f}(e - d_1, \theta_B))}, \quad q_1^B = \frac{y}{u'(c_{1f}(e - d_1, \theta_B))}.$$

If the atomic household moves to the new city, she becomes borrowing-constrained as well, attaining

$$c_1^B = \underbrace{e - d_1 + \frac{\kappa y - \theta_B v'(T)T}{u'(c_{1f}(e - d_1, \theta_B))}}_{=c_{1f}(e-d_1,\theta_B)} - M(\theta; \theta_B)$$
$$= c_{1f}(e - d_1, \theta_B) - M(\theta; \theta_B). \tag{34}$$

She compares c_1^B in (34) with her current consumption in the old city $c_{1f}(e - d_1, \theta)$. If

$$c_{1f}(e - d_1, \theta) > c_1^B = c_{1f}(e - d_1, \theta_B) - M(\theta; \theta_B),$$

which is equivalent to

$$M(\theta; \theta_B) > c_{1f}(e - d_1, \theta_B) - c_{1f}(e - d_1, \theta), \tag{35}$$

the atomic household stays in the current city, enduring a large inefficiency stemming from the pecuniary change in electricity.

Defining

$$\check{M}(\theta; \theta_B) \equiv c_{1f}(e - d_1, \theta_B) - c_{1f}(e - d_1, \theta),$$

which is increasing in θ, we obtain the following result:

Proposition 3. *With $\theta_B > \theta^*(d_1)$, a large moving cost, satisfying*

$$M(\theta; \theta_B) > \check{M}(\theta; \theta_B),$$

leads to pecuniary externalities and efficiency losses as the atomic households do not relocate to the new city.

In Figure 4's case, the atomic household moves only if $\theta > \hat{\hat{\theta}}(\theta_B)$, i.e., the price impact is too strong. Still, she cannot achieve the efficient consumption level in the new city. Here, the demand parameter threshold $\hat{\hat{\theta}}(\theta_B)$ is defined by

$$M\left(\hat{\hat{\theta}}(\theta_B), \theta_B\right) = \check{M}\left(\hat{\hat{\theta}}(\theta_B), \theta_B\right).$$

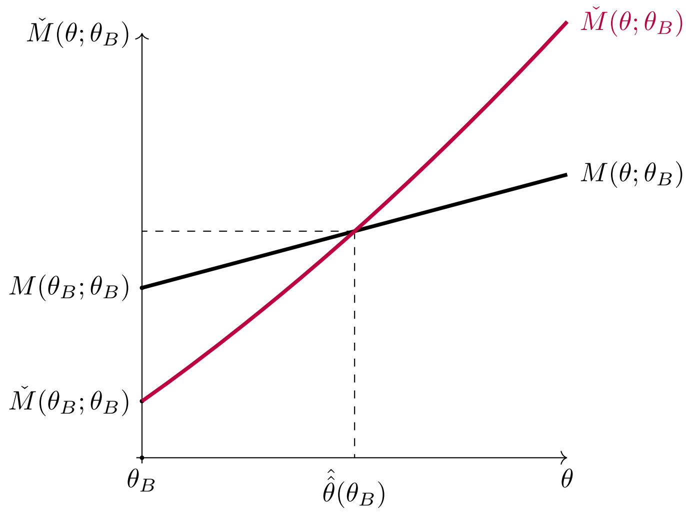

Figure 4: Realistic Case: $M(\theta;\theta_B)$ and $\check{M}(\theta;\theta_B)$

3 Conclusion

With the rapid growth of data centers across different U.S. regions, concerns have emerged regarding their potential to drive up electricity prices, thereby burdening residential households with higher utility bills. We introduce a stylized, tractable framework to demonstrate how pecuniary externalities from higher electricity demand (and prices) can occur and compromise efficiency in the presence of market frictions. We focus on market frictions such as borrowing constraints and the costs involved in relocating to alternative locations. Such frictions hinder households from responding optimally to fluctuations in electricity prices, thereby generating pecuniary externalities that reduce overall efficiency. We explore several potential policy interventions, both from the government and technology firms involved in constructing data centers.

The extent to which recent spikes in electricity prices can be linked to the construction of new data centers remains an empirical question, as some research suggests that data centers may actually lower electricity costs for average users by contributing to infrastructure improvements, such as new substations and transmission lines. Exploring the magnitude of pecuniary externalities caused by these newly established data centers and quantitatively assessing their impacts on overall welfare through structural approach presents a promising avenue for future research.

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