

The Rebound Effect: introduction and historical perspective

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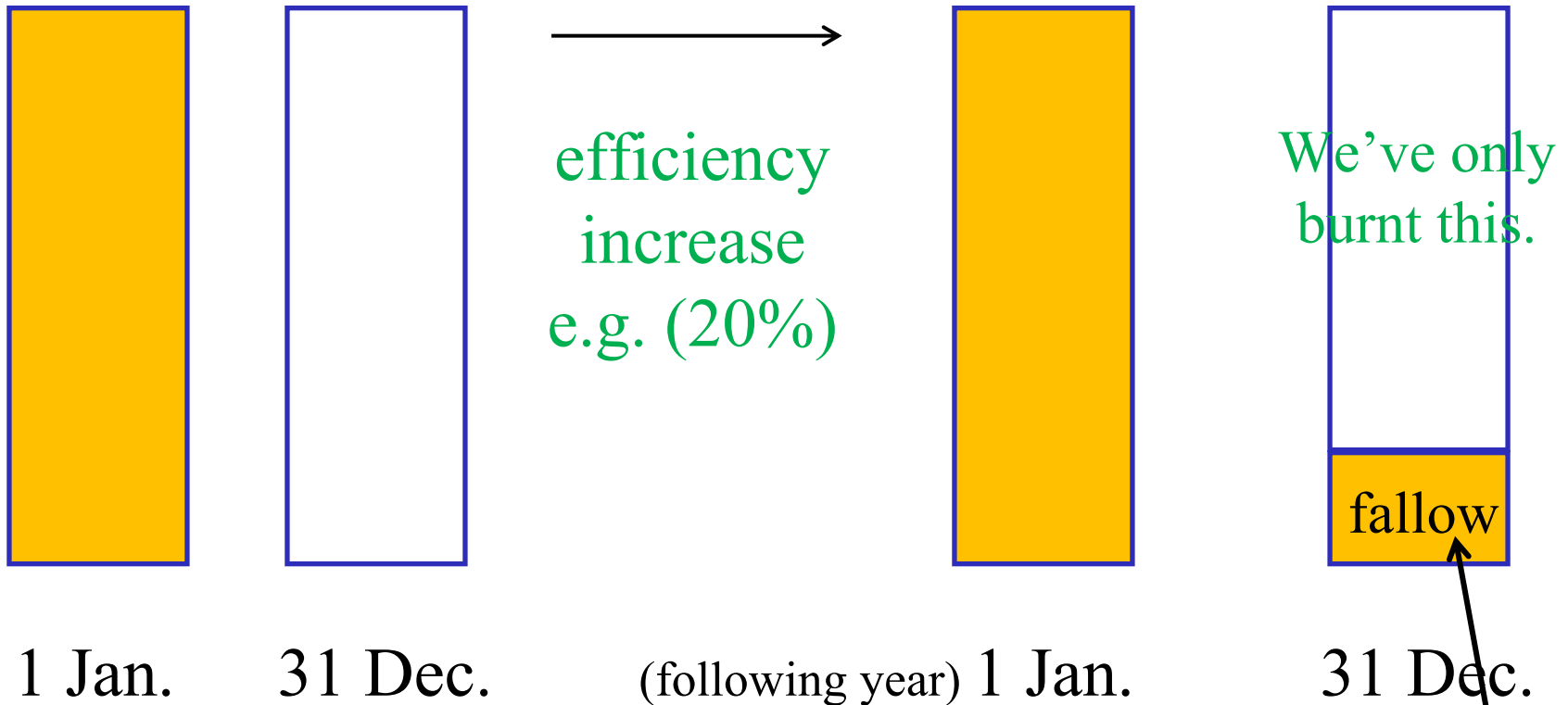
Questions

1. Is energy-**efficiency** policy necessary and sufficient for energy **conservation**?
2. Where lies the **burden of proof**? That rebound is 'high', e.g. 50-100%? Or that increased energy efficiency really reduces energy consumption.
3. What are the consequences for environmental energy policy in light of **high uncertainty** over rebound?

& familiarity with concepts

Fallow energy (intuitive)

 = fossil fuel



'Reboundology' asks, What do we do with **this**?

Basic Definitions

1. What is “energy efficiency”?
2. What is “engineering savings”?
3. What “rebounds”?
4. What is “backfire”?

energy efficiency

OUTPUT

INPUT (*a ratio, an intensive quantity*)

input: energy in joules

output: 1) in policy – physically defined

(heat, work, light)

2) in academia – monetarily defined

(\$ unit of GDP, sometimes utility)

business-as-usual
policy-induced

Warning: “product” changes over time.

engineering savings

- Keep # of output-units constant (e.g. lumen-hours or tonne-kilometres or tonnes of steel)
- Measure Δ energy-efficiency *in %*: each output-unit needs **X** less joules
- Multiply **1 minus this %** times # output-units
- Deduct **embodied energy** in equipment replacement process over product “lifetime”
- This is an *extensive quantity*, a # of joules

*a theoretical quantity of energy – which **could be** saved **if** # of output units in reality stays the same*

rebound

new consumption *of energy* (= the input) following the efficiency increase

- because joules have been freed from previous uses
- because one has more purchasing power
- because energy is now more ‘attractive’ compared to other production factors

given in % of engineering savings!

rebound taxonomy: direct + indirect = economy-wide or (the policy-relevant quantity) **total rebound**

backfire

rebound $> 100\%$ (of theoretical ‘engineering’ savings)

a.k.a. Jevons’ Paradox or the Khazzoom-Brookes postulate

Maybe society burns or ‘takes back’ more than what could theoretically be saved!

From the ‘environmental point of view’, this would not mean merely that efficiency policy is ineffective, but even that is counter-productive, i.e. “backfires”.

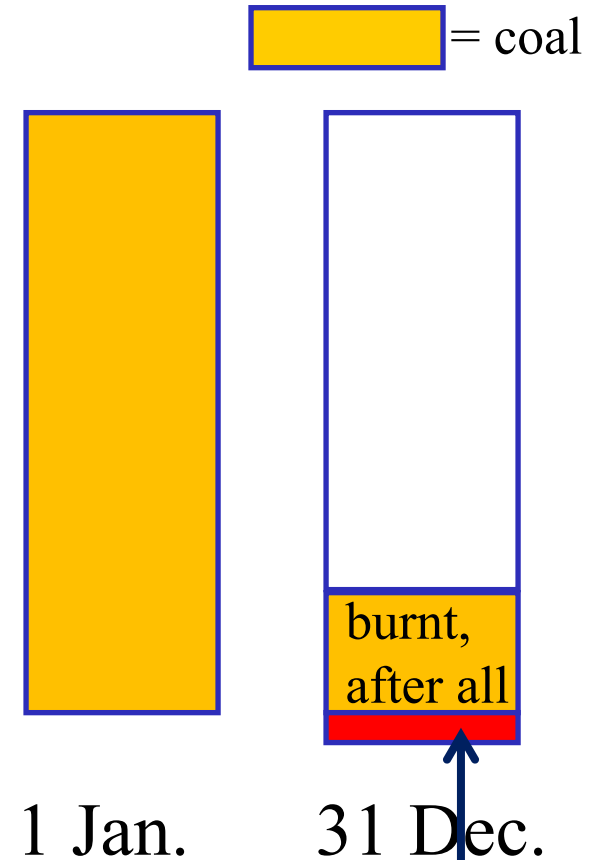
Wm. Stanley Jevons' *The Coal Question*

(1865)

Big worry: **peak coal**

Many said, 'Not to worry, we're using coal ever more **efficiently.**'

Jevons: 'Yes, but that means we burn *even more.*'



The **paradox**: without efficiency, we wouldn't use **this**.

Jevons' Arguments in a Nutshell

Costs of production fall

- Profits rise
- Prices fall
- Sales increase
- Therefore energy inputs in total (not per unit of production) rise – but how high (proves rebound but not backfire)?

Empirical evidence* correlating steam-engine efficiency and coal consumption

Analogy with *labour* inputs

Empirical evidence, today

- Like Jevons', some **sectoral** as well as **country** studies show very high *correlation* between efficiency increase and consumption increase.
- I.e. £GDP pro Joule rises proportionally with # Joules consumed.
- But regression analysis necessary – **worldwide** for climate change problem.

Labour Analogy

$$Q \text{ (“product”)} = f(\text{Land}^*, \text{Labour})$$

Long debate between Ricardo, Owen, Luddites, Sismondi & Marx – who said **labour**-efficiency rebound is *less than* 100%, and

- Say, Malthus, McCulloch, Mill, & Jevons, who said labour-efficiency rebound is *more than* 100% of possible **labour** savings, i.e. results in even more **employment** and **population**
- applied to **energy** inputs this is Jevons’ Paradox (*The Coal Question*, 1865): Rebound > 100%

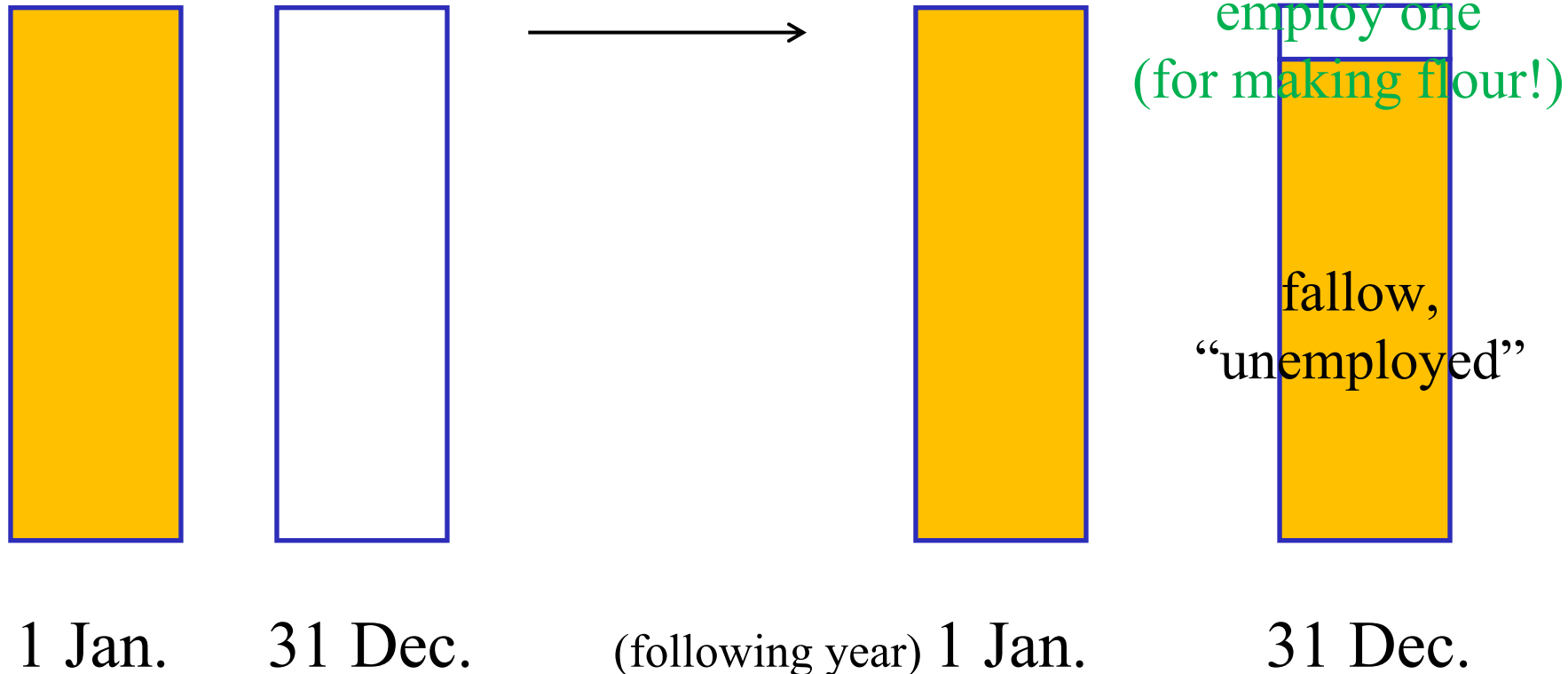
Consensus on labour efficiency

[In] a stationary condition of capital and population... the industrial arts might be as earnestly and successfully cultivated, with this sole difference, that instead of serving no purpose but the increase of wealth, industrial improvements [efficiency] would produce their legitimate effect, that of abridging labour [unemployment]. Hitherto it is questionable if all the mechanical inventions [efficiency] yet made have lightened the day's toil of any human being.

John Stuart Mill, 1848

Jean-Baptiste Say (1820) : A flour mill throws 19 of 20 out of work

Labour, # of workers



Say: The flour, the bread, is still there! The laid-off workers **produce something else.**

Say, Malthus, Mill, Jevons etc.

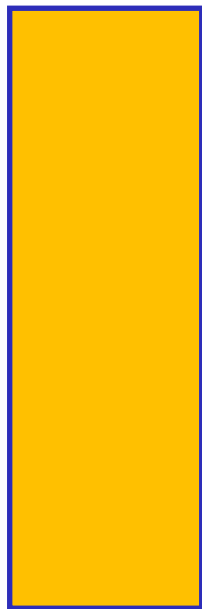
Labour-input rebound may not “backfire” but is about 100%.

Plausible that society somehow uses the fallow-lying **labour** – for more goods and services and/or greater population.

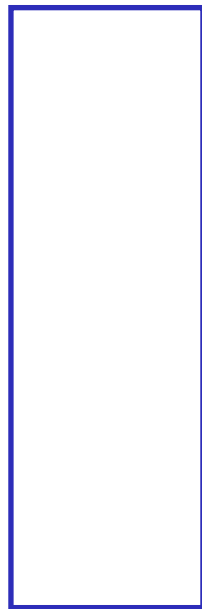
And energy? **Plausible**, but not *proven*, that ‘unemployed’ joules ‘find work’.

Fallow energy again

 = fossil fuel



1 Jan.



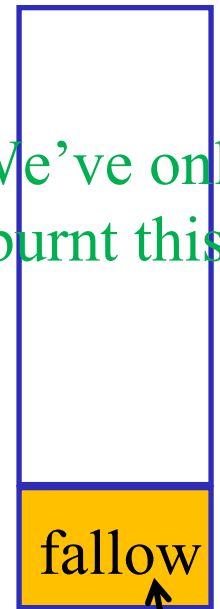
31 Dec.



efficiency
increase,
night of
31 Dec.
(20%)



(following year) 1 Jan.



fallow

31 Dec.

We've only
burnt this.

What do we do with **this**?

Before Jevons

- Say: # units produced increases “outruns” efficiency per unit produced: i.e. **backfire**
- Sector evidence for at least **R = 100**: favourite examples textile products, iron production, and publishing (due mostly to labour efficiency increases)
- But pollution and peak coal problems not on the table till Jevons

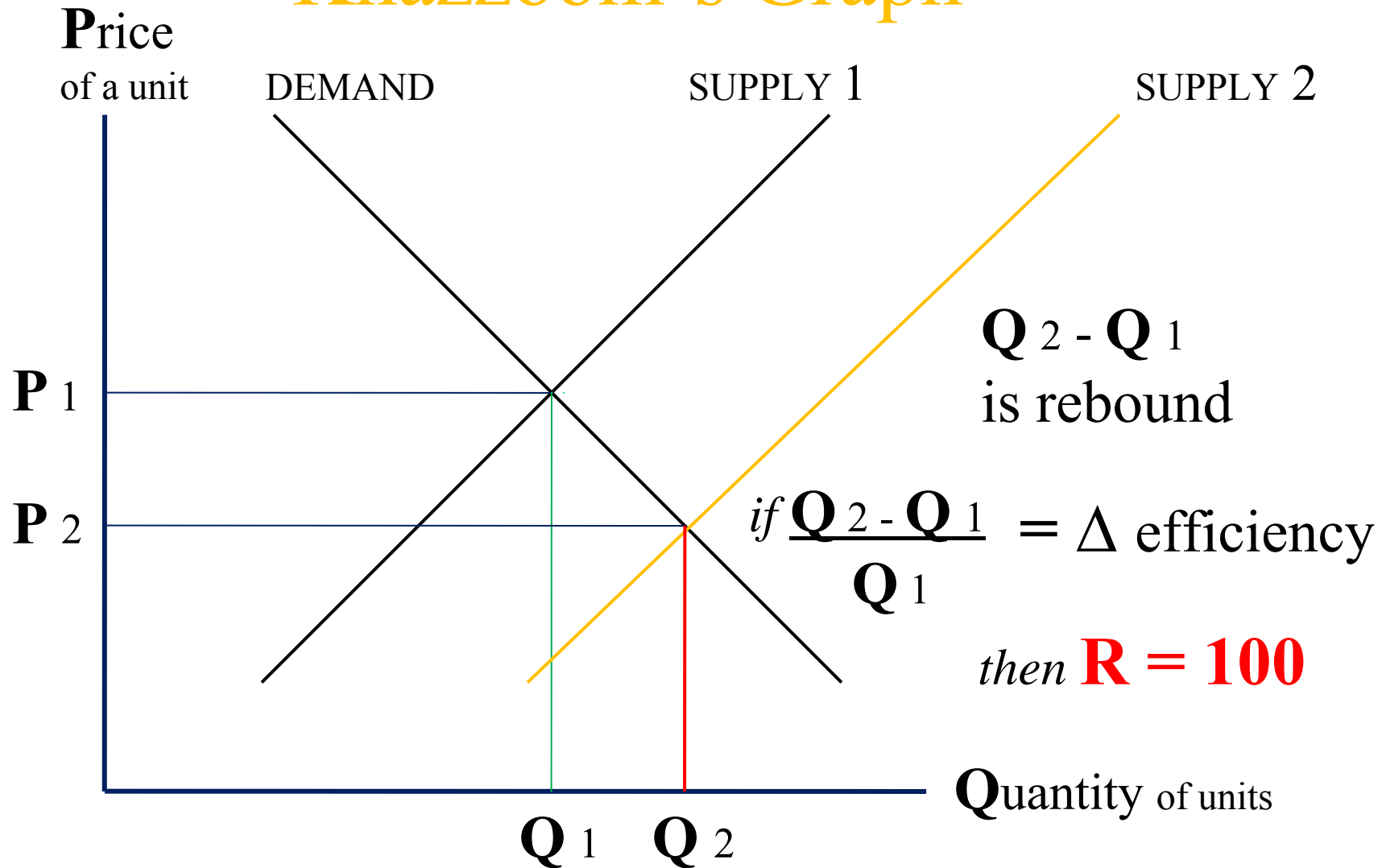
Classical economists conceptualized many of today's 'rebound' concepts

1. From Petty to Jevons: efficiency is **either** same output, less input **or** same input, more output
2. Efficiency means **price falls** and more goods and services “that nobody pays for” (Say 1803)
3. Efficiency means a (societal) **income effect**

(continued)

5. They saw “indirect” rebound, i.e. new purchasing power used by previous or marginal consumers for goods **other than** the ones now more efficiently produced.
6. **Population** (at least partly) **endogenous**: from Malthus on, increased efficiency meant more consumers.
7. They (mainly Malthus!) saw the “**indolence**” option: we *could* take efficiency dividends in the form of non-production, non-consumption: i.e. Rebound would = **0** (but not real life).

Jump to 1980: Khazzoom's Graph



Forget Jevons' Paradox

- Paradoxes fun but just too difficult.
- For *policy*, we only need to know if R is at or only slightly below 100.
- At 100, it efficiency policy is environmentally *ineffective*.
- Between roughly 80 and 100 it becomes *cost-ineffective*.

What does history, empirical study, psychology, maybe anthropology tell us: Do we use the no-longer-needed, fallow resources, or not?

Is increased energy **efficiency** necessary and sufficient for energy **conservation**?

- Not *necessary* because either energy rationing or high energy taxes would by definition achieve conservation
- My conjecture: It is not *sufficient* because the world economy most likely uses up whatever energy is “freed” through efficiency – additional **economic activity** and additional **population**

Possible policy conclusion

Efficiency is good!

- for cutting production costs
- for higher profits
- for affluence and economic growth
- for getting the most utility out of a given amount of energy
- for heightening political acceptance for caps and high taxes!!

But as rebound approaches 100%, it becomes *less environmentally effective*, and **rationing** or **taxes** are better policy.

Upon which assertion lies the **burden of proof?**

1. Rebound is about 100%.
2. Increased energy efficiency in fact conserves energy.

1: 'systems' or whole-society point of view

2: engineering, *per-unit* point of view

Nothing *proven* yet

- Since Khazzoom & Brookes 30 years ago, policy has treated R as **zero**.
- If a consensus emerges that R is between 50 and 100, the argument for direct, *necessarily effective* conservation policy is strengthened: **taxes or quotas**.
- Given taxes or quotas, efficiency (and sufficiency) follows as a matter of course.

Beauty and the Bald Head



She's got ya there!

So what are you for, *less* efficiency, or what?

Reboundologist
(oldtimer)

Questions and Objections, please

Engineering vs. economics

“Unfortunately, the estimates of energy savings predicted to result from... mandated [efficiency] standards are derived **mechanically**... These calculations overlook the fact that changes in appliance efficiency have a **price content.**”

(Khazzoom 1980)



Assumed Reference Scenarios

“Note that ‘energy saving’ does not imply that total energy use will be lower, only ‘**less than otherwise**’.”

(Schipper & Grubb 2000)

“A program of...efficiency improvement is likely to lead...to a net increase in energy consumption **greater than** it would have been **otherwise**.”

(Khazzoom 1980)



Ceramic stove replaces open fireplace

Wood remains standing for other uses and/or other people.

(wood left standing)

wood left standing

house

firewood

1/2

Example **space**-input

farmed land

unfarmed land

Agricultural productivity goes up. [\(Pascual 2002\)](#)

Does higher farm productivity (yield/hectare) – an undoubted historical fact – mean we have **taken land out of cultivation** (or even kept only the same)? No.

Laziness

- Rebound = 0 at full consumer saturation, i.e. at 0 price elasticity of demand
- Malthus elaborated: A steep or vertical demand curve results if we take efficiency gains in the form of “*indolence*”. He and Mill were for it.
- However, there are 2,000,000,000 very poor people on earth, 3,000,000,000 who want ‘a little bit more’, and 1,000,000,000 doing Veblen’s “conspicuous consumption”.

Who can answer the empirical question of latent demand by attesting anything even close to saturation?

Two weird strategies

‘The method ordinarily proposed to stop the wholesale devastation of irreplaceable natural resources, or of natural resources replaceable only with difficulty and long delay, is to **forbid production** at certain times and in certain regions or to hamper production by insisting that **obsolete and inefficient methods** be continued.’

(Hotelling 1931)

inefficiency strategy!

An ad hominem slide

“The supply of capital... and the supply of labour... [determine] the national dividend... A more complicated problem has to be faced when the initiating cause is an invention or improvement in processes or methods..., since they enable something to be produced which was not being produced before, or enable something which was being produced before to be produced more easily, must increase the national dividend.”

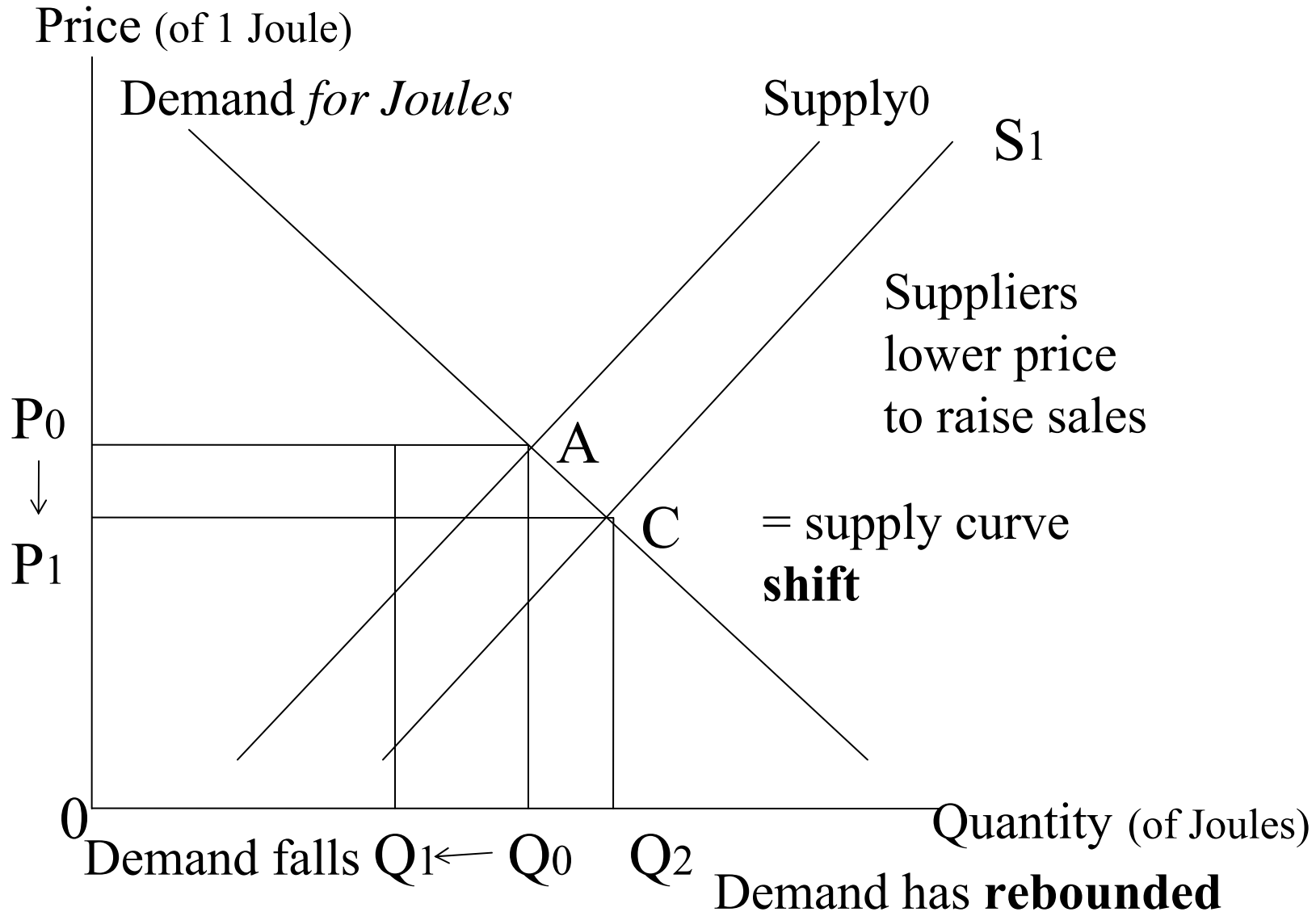
(Pigou 1920)

BAU-Cases

- “When energy price or availability constrains demand...the apparent savings from using more efficient technologies would be largely offset by the macroeconomic response – the tendency to use more energy services because they are made cheaper.” Michael Grubb 1990, p 783 (*Energy Policy* 18 (8): 783-785 – answer to Brookes)
- What does “constrain” mean here?
- Does “largely offset” mean R close to 100?

3) Lessons

Price fall of energy itself



Literature

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