Discussion of "Moore's Law and Economic Growth"

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What is the Paper About?

- New model of recombinant growth
- Question: What limits to the set of feasible combinations of inputs/ideas and long run growth?
- This paper opens the black box of new product creation by considering physical constraints limiting feasible new products
- Considering weight constraint as an example, the model shows how miniaturization can lead to productivity gains in the long run

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  - **Kortum (1997)**: new ideas arise with random productivity. Productivity is the best draw so far. Pareto tail distribution + exponential growth in draws $\Rightarrow$ exponential growth.
  - **Jones (2021)**: combinatorial growth in the number of draws can lead to exponential growth with thin-tail distributions.

What is Driving Growth in the Current Model? A Simplified Version of the Model 1

- Infinite number of primary goods X_i with $i \in \{1, 2, 3...\}$ (marginal cost normalized to 1).
- Leontief production technology: $Y = A(S) min_{i \in S}(X_i)$
- Weight constraint: $\sum_{i \in S} \theta_i < \tau$ where θ_i is the weight of primary good i.
- Let $\mathcal{F}_t$ be the set of primary good combinations that satisfy the weight constraint at time t.
- $A(S) = \phi(S)|S|$ with $\phi(S)$ being draws from i.i.d Fréchet distributions with shape parameter κ and scale parameter 1.

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- We obtain $Y_t = \phi(S)$
- The optimal set of primary goods is $S_t^* = argmax_{S \in \mathcal{F}_t} \phi(S)$
- And the growth rate of the economy is given by: $g_t = \frac{1}{\kappa} \Delta log \left(|\mathcal{F}_t| \right)$

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- Long run exponential growth if
  1. Growth in the number of feasible combinations over time $\Rightarrow$ Weitzman (1998)
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- Why does the number draws grow exponentially? Because weight of inputs decreases exponentially $\Rightarrow$ Moore's law

Comment 1: Moore's Law and Marginal Costs

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- In the general version of the model, output can be written as $Y_t = \frac{1}{\kappa} log \left(\sum_{S \in \mathcal{F}_t} \bar{K}(S, P, \tau)^{-\kappa} \right) + constant$, where $\bar{K}(S, P, \tau)$ relates to marginal cost.
- What if there is exponential decrease in marginal cost? Can exponential growth be maintained?

$\Rightarrow$ Framework to decompose the effect of miniaturization between physical constraint and primary good productivity improvement?

Comment 2: Moore's Law and Feasible Sets

- Moore's law can generate exponential growth in $\mathcal{F}_t$

Figure: Feasible Combinations and Input Weight

t	$\theta_1(t)$	$\theta_2(t)$	$\theta_3(t)$	$\theta_4(t)$	$\lvert\mathcal{F}(t)\rvert$
1	0.5	1	2	4	1
2	0.25	0.5	1	2	3
3	0.125	0.25	0.5	1	7

- More than exponential growth in the number of combinations involving several units of the same product (higher quality?)
- Jones (2021) shows that faster than exponential growth in the number of draws can lead to exponential growth with "thin-tail" distributions

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- Bloom et al. (2020) suggest that the amount of resources needed to maintain Moore's law have increased over time

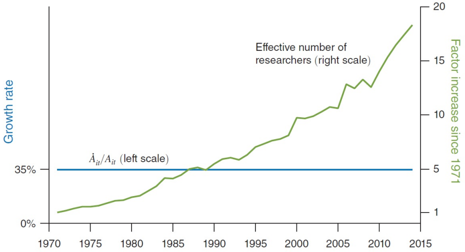

FIGURE 4. DATA ON MOORE'S LAW

Notes: The effective number of researchers is measured by deflating the nominal semiconductor R&D expenditures of key firms by the average wage of high-skilled workers and is normalized to 1 in 1970. The R&D data include research by Intel, Fairchild, National Semiconductor, Texas Instruments, Motorola, and more than two dozen other semiconductor firms and equipment manufacturers; see Table 1 for more details.

Source: Bloom et al. (2020)

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- Model is used to quantitify the effect of Moore's law on TFP growth since the 1960s
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- Other relevant physical constraints? Solar energy/panel? Batteries? $\Rightarrow$ Climate change and policy?

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  3. Revenue shares depend on market structure
- Can historical input-output tables be used for external validation:
  - How do changes in estimated number of combinations at the industry level correlate with product share of industry revenues?
- Use data on the evolution of resources into Moore's law (Bloom et al, 2020) to decompose the productivity effect of miniaturization through feasible combinations vs reduction in marginal cost of production