Australian National University

EE468: Integrated Public Economics, Development and Political Economics

Lecture 4: Nutrition

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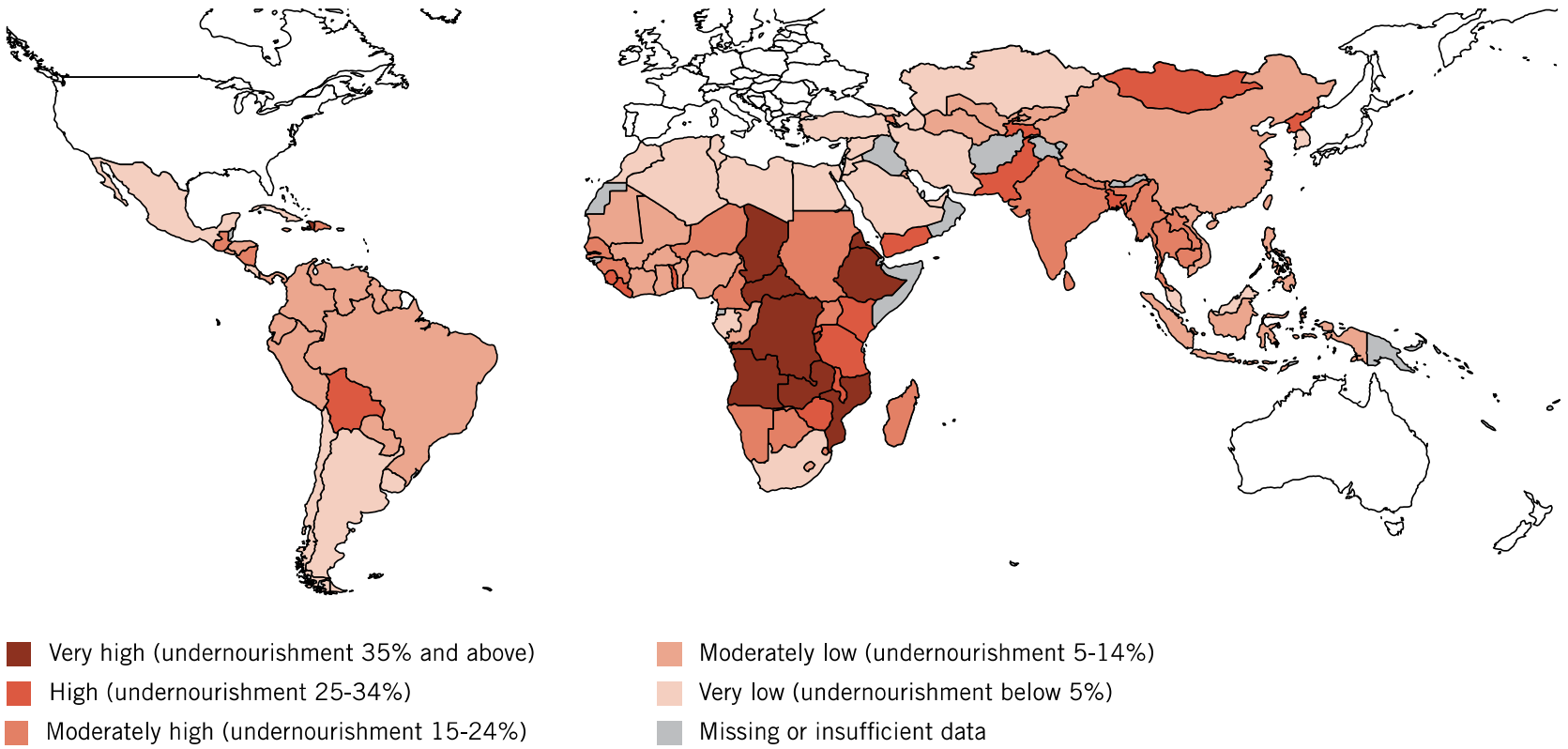
Outline

- A simple model of nutrition and productivity
- Understand nutrition-productivity relationships and how they interplay with poverty empirically
- Policy implications

Motivating evidence

- While famine may be history, malnutrition is not! A billion people are still under nourished according to the UN FAO
- From the Millennium Development Report:

Proportion of undernourished population, 2005-2007 (Percentage)

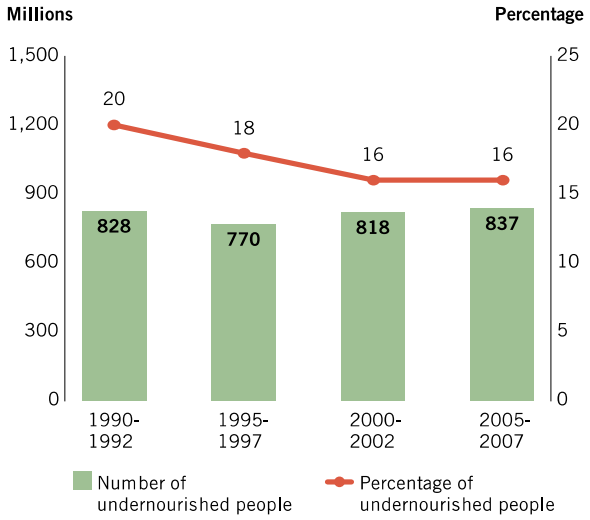


Motivating evidence

- But despite good reduction in poverty, various undernutrition measures remain high
- Alleviation of hunger and undernutrition is thus one of the key development goals!

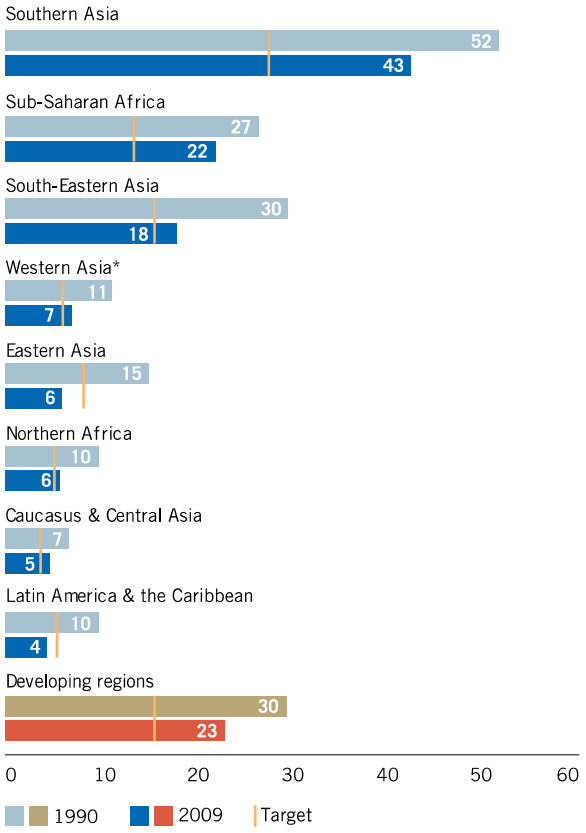
The proportion of people going hungry has plateaued at 16 per cent, despite reductions in poverty

Number and proportion of people in the developing regions who are undernourished, 1990-1992, 1995-1997, 2000-2002 and 2005-2007



Nearly a quarter of children under five in the developing world remain undernourished

Proportion of children under age five who are underweight, 1990 and 2009 (Percentage)

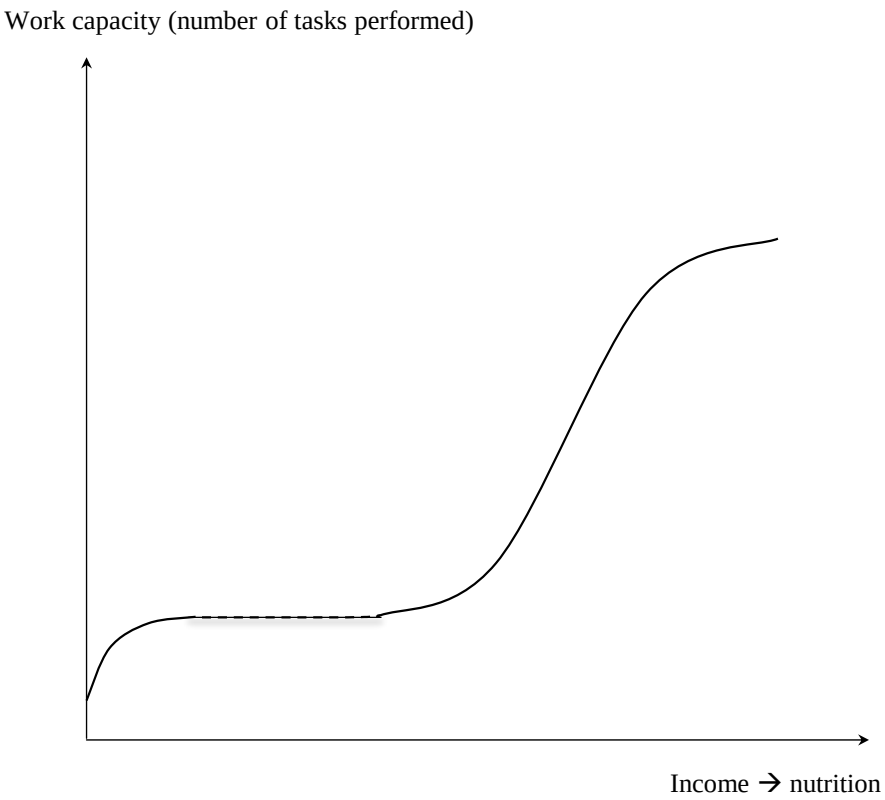


Motivating evidence and policy questions

- Undernutrition could cause irreversible damage to human capital accumulation:
  - Stunting, muscle wastage, increased susceptibility to illness, reduced cognitive skills in children and diminished immunity to disease in adults
- Undernutrition can feed back on a person's capacity to work and thus perpetuating the stage of poverty (i.e., nutrition-based poverty trap)
  - Low nutrition → low productivity → low income → low nutrition
- Puzzling evidence of small nutrition intake response to income and the declining trend over time
- <u>The key policy questions</u>:
  - How might nutrition-productivity relationships interplay with persistent poverty?
  - How do nutrition-income relationships look like empirically?
  - What do these imply about policy design and targeting to improve nutritional status among the poor?

A model of nutrition and productivity (Dasgupta & Ray)

- Let's first understand how nutrition-productivity relationship interplay with poverty
- Imagine a poor individual who works for a piece-rate job, earn daily income, which he then can use to afford daily food/nutrition
- **The capacity curve**: relates income and work capacity (productivity)

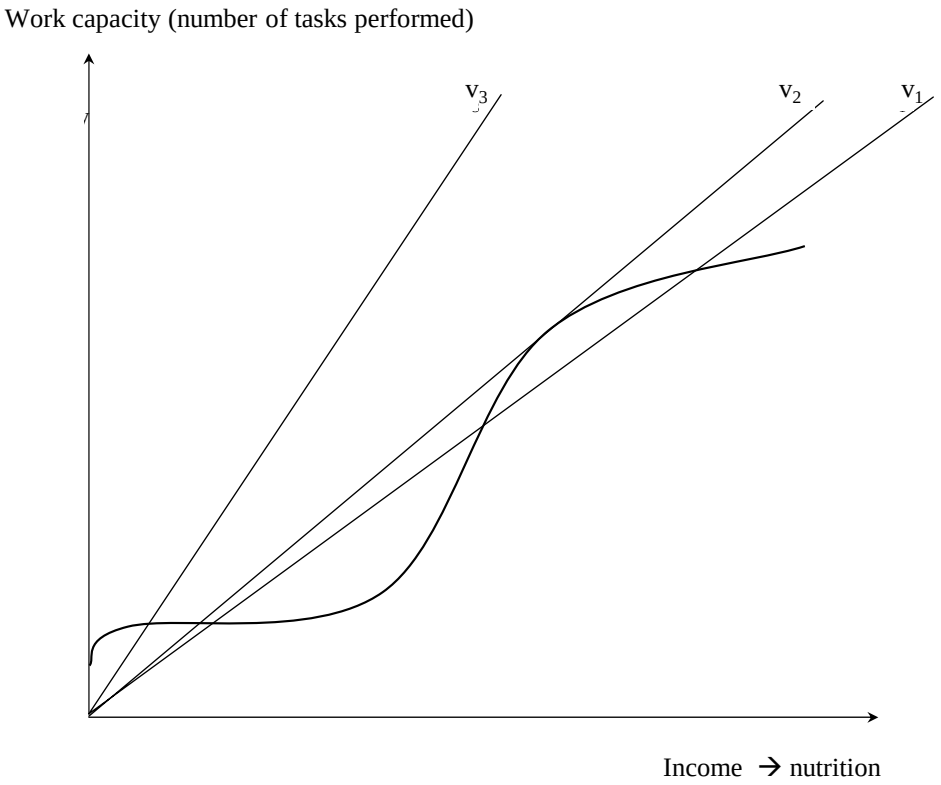


- Higher income → better nutrition
- Better nutrition first used for basic metabolism, the rest then translate into high work capacity with diminishing return governed by body limit
- Hence, convex, s-shape capacity curve

→ **Income thus determines work capacity through nutrition**

A model of nutrition and productivity (Dasgupta & Ray)

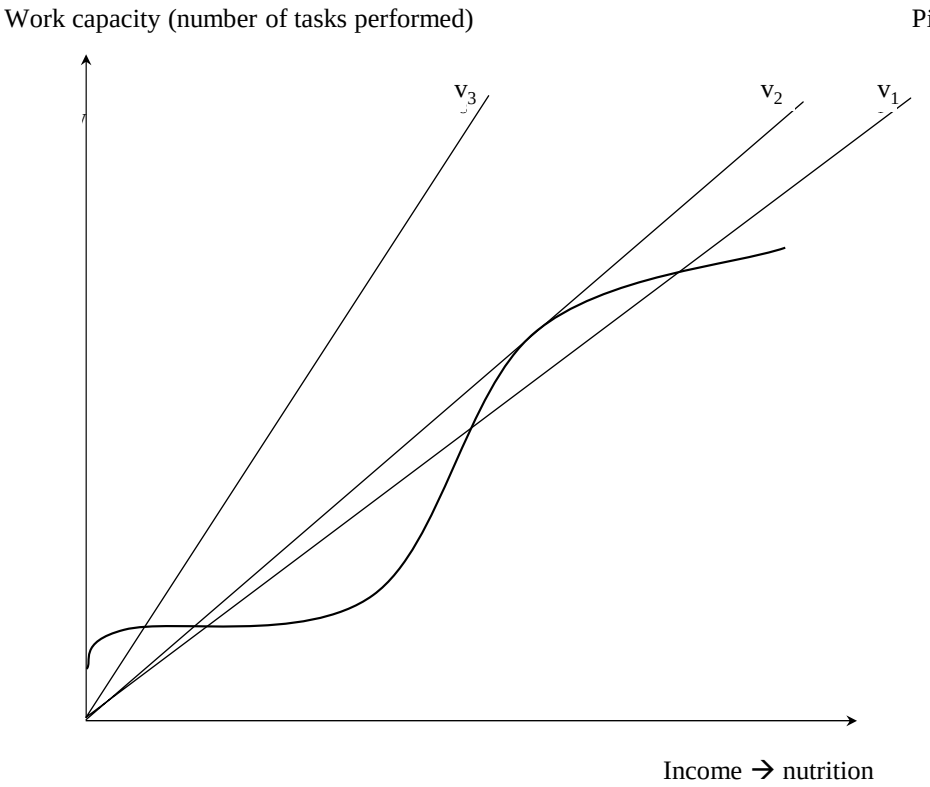
- **A piece-rate schedule**: income earned for each task performed at any given market rate

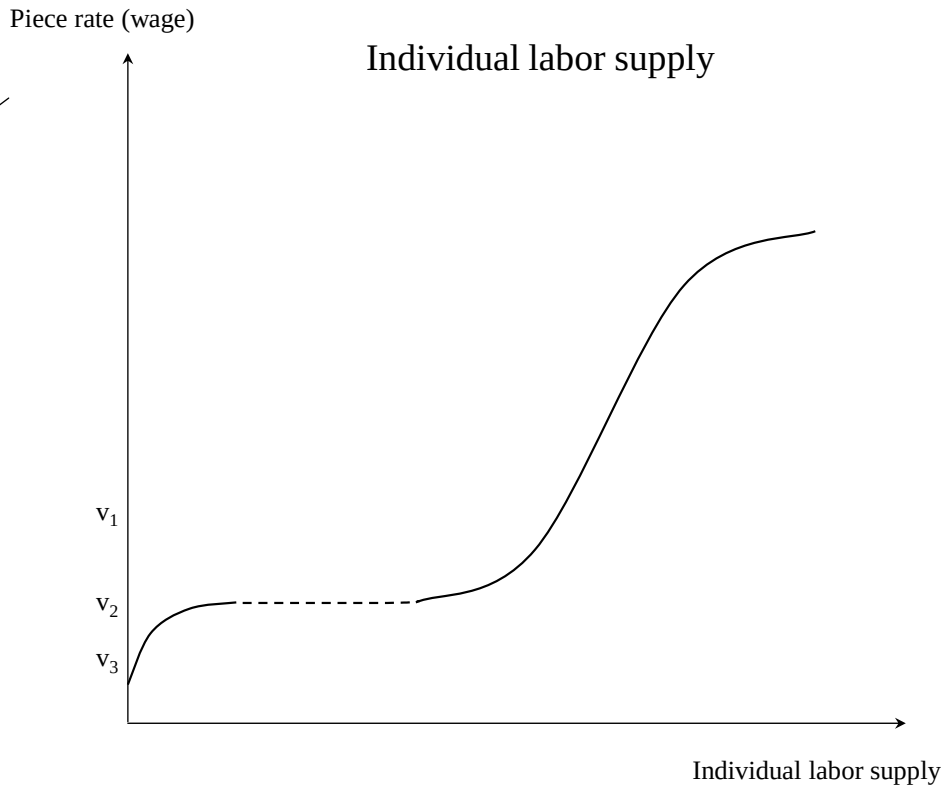


- The piece rate $v_1 > v_2 > v_3$
- Individual will try to work as much as they can at a given market piece rate given constraints imposed by capacity curve
- For each individual, there exists a minimum piece rate (v_2) below which the rate is insufficient to sustain necessary nutrition needed to work
- This is called “nutrition efficiency wage”
- If $v < v_2$, labor supply jump down discontinuously

A model of nutrition and productivity (Dasgupta & Ray)

- **Labor supply**: Gap in labor supply at the nutrition efficiency wage v_2 below which the potential income earned will be too small to sustain enough nutrition and productivity necessary for the job

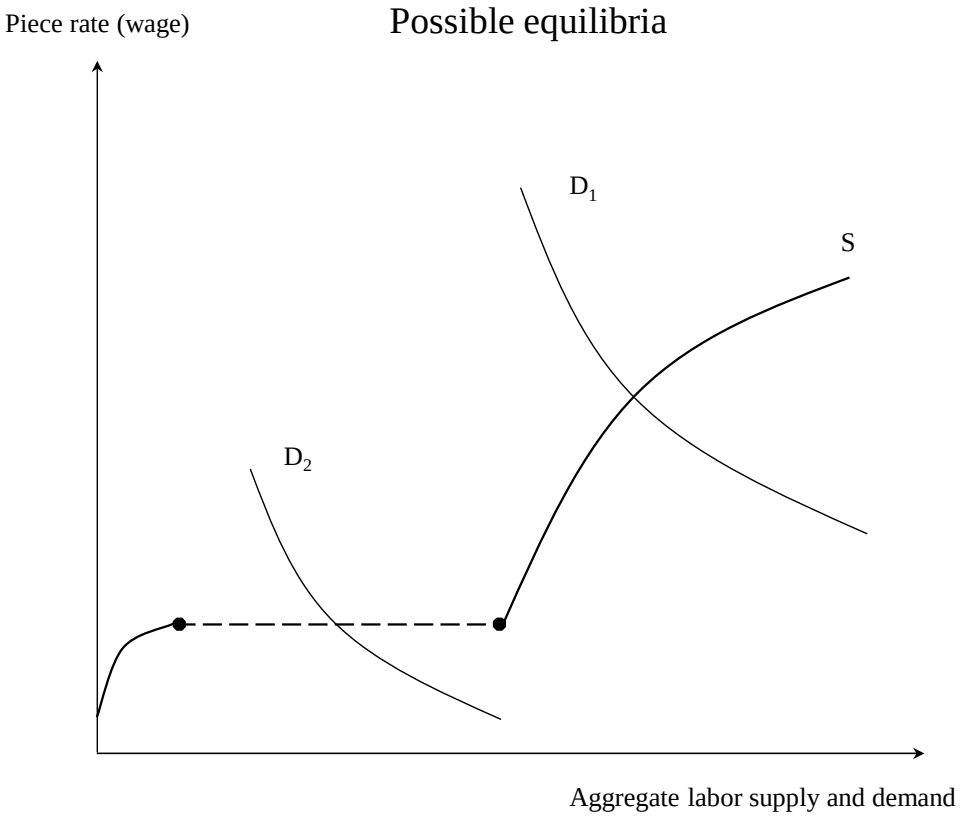




- Aggregate labor supply can then be obtained by multiplying the individual curve by number of laborers

A model of nutrition and productivity (Dasgupta & Ray)

- **Market equilibrium**: depends on quantity of demand relative to supply

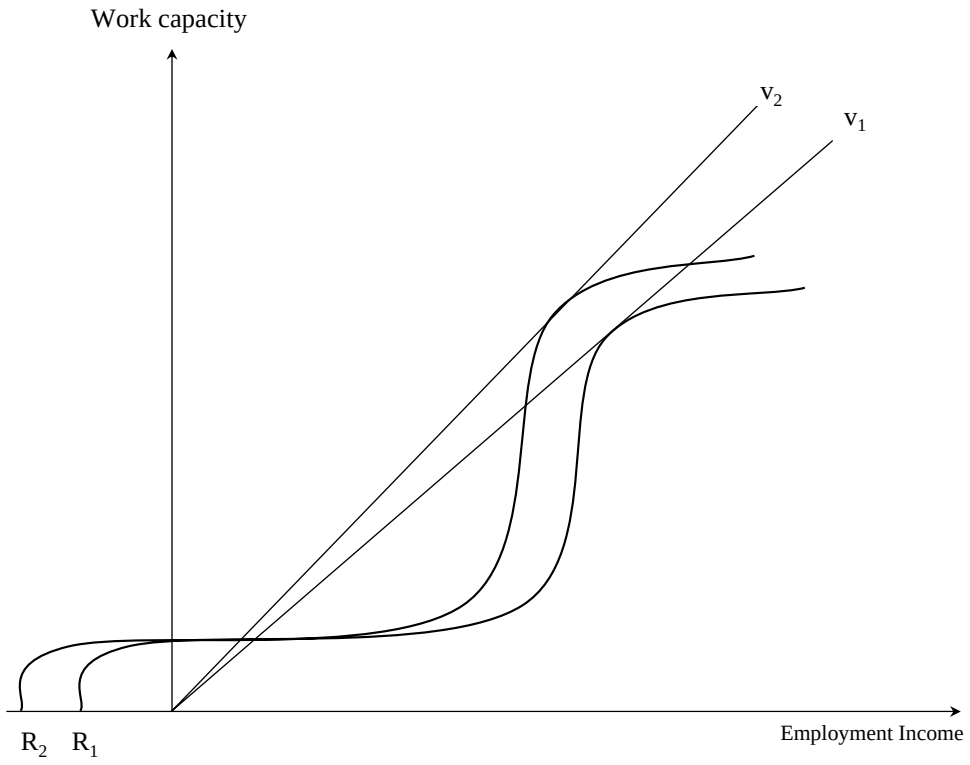


- If demand is large relative to supply (D_1), everyone gets to supply high level of work efforts, which yields high level of nutrition
- If demand is small relative to supply (D_2) and cross supply in the gap, equilibrium exists with "involuntary unemployment"
- If individuals share identical capacity curve, a person is involuntarily unemployed as he cannot find employment in the market which does employ a person similar to him

- The vicious circle is complete, low wage leads to reduced nutrition and work capacity, which then closes access to employment!

A model of nutrition and productivity (Dasgupta & Ray)

➢ **The effect of non-labor income (e.g., from asset owned) on capacity curve**

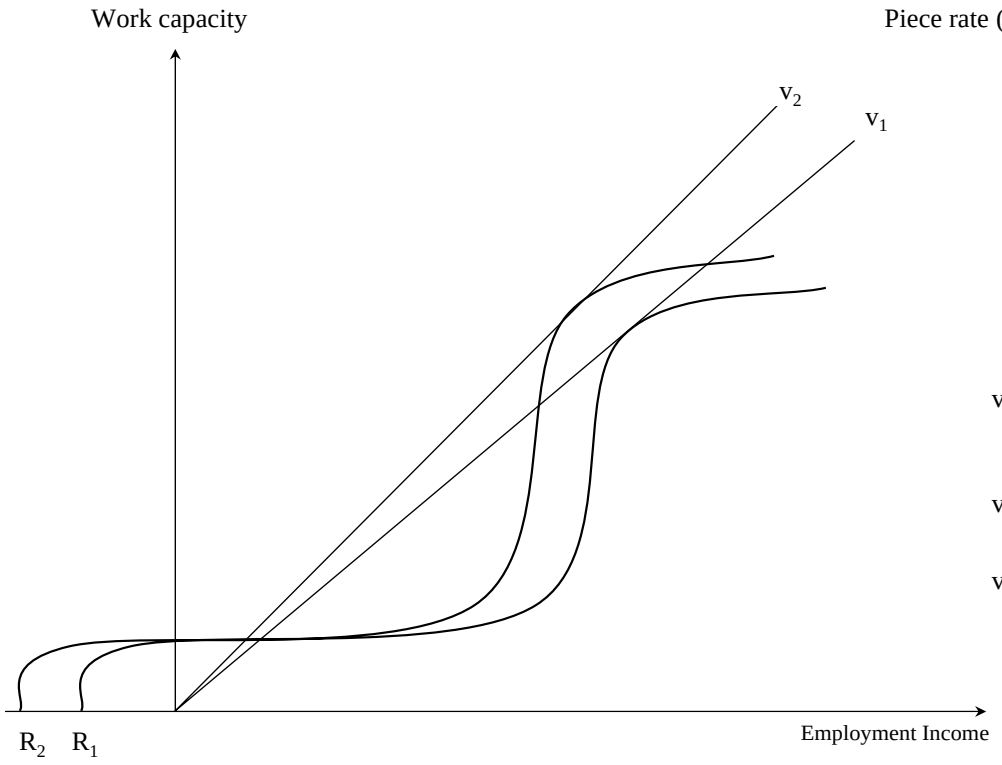


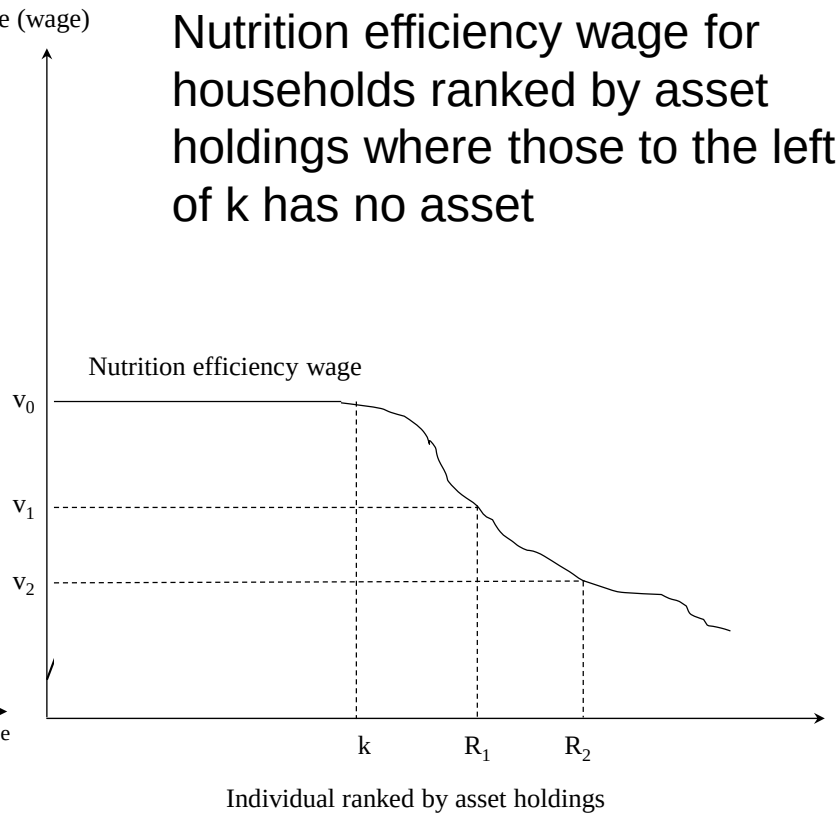
- Non-labor income can also be used to afford better productivity
- At $R_2 > R_1$, which direction would R move capacity curve?
- Who are more likely to be employed at low wage v_2?
- When both are employed (e.g., at v_1), who can work more and earns larger wage income?
- People with small assets are doubly cursed. Not only do they not enjoy non-labor income, they are at a disadvantage in labor market

- The vicious circle of inequality: the functioning of the labor market further magnifies asset inequality

A model of nutrition and productivity (Dasgupta & Ray)

- **The effect of non-labor income on nutrition efficiency wage schedule**



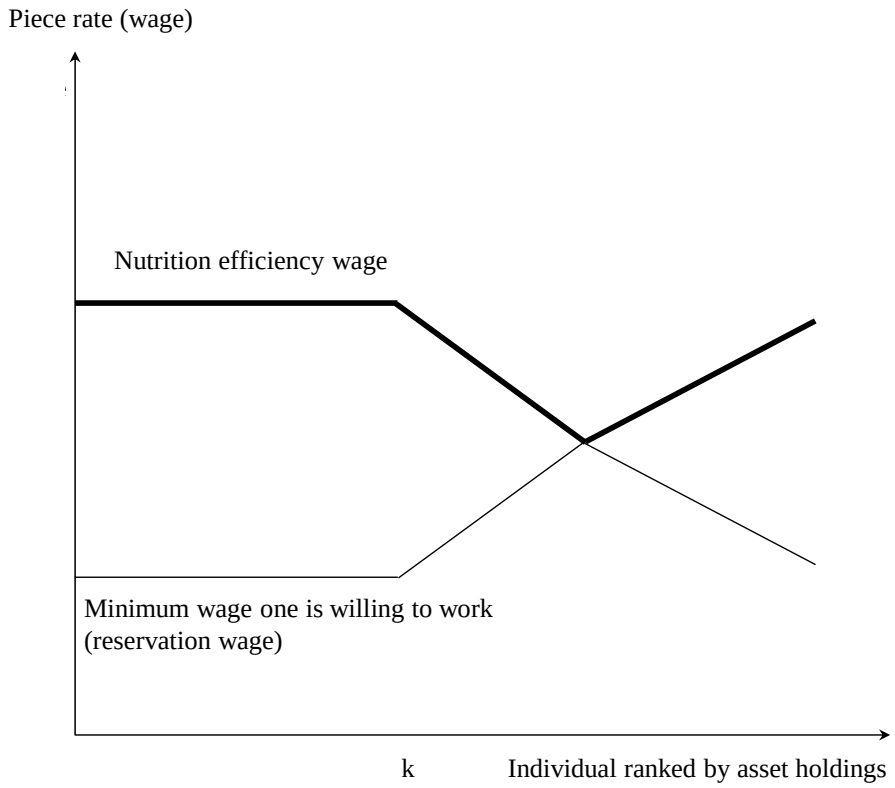


Nutrition efficiency wage for households ranked by asset holdings where those to the left of k has no asset

- People with greater assets are able to supply labor at a lower efficiency wage as their non-labor income takes care of some of their nutritional needs

Model of Nutrition and Productivity (Dasgupta & Ray)

➢ **The effect of non-labor income on minimum wage that people can and are willing to work**



- Capacity curve and labor supply

  As non-labor income (wealth) increases, min. wage that someone can work (nutrition efficiency wage) decreases

- Willingness to work and labor supply

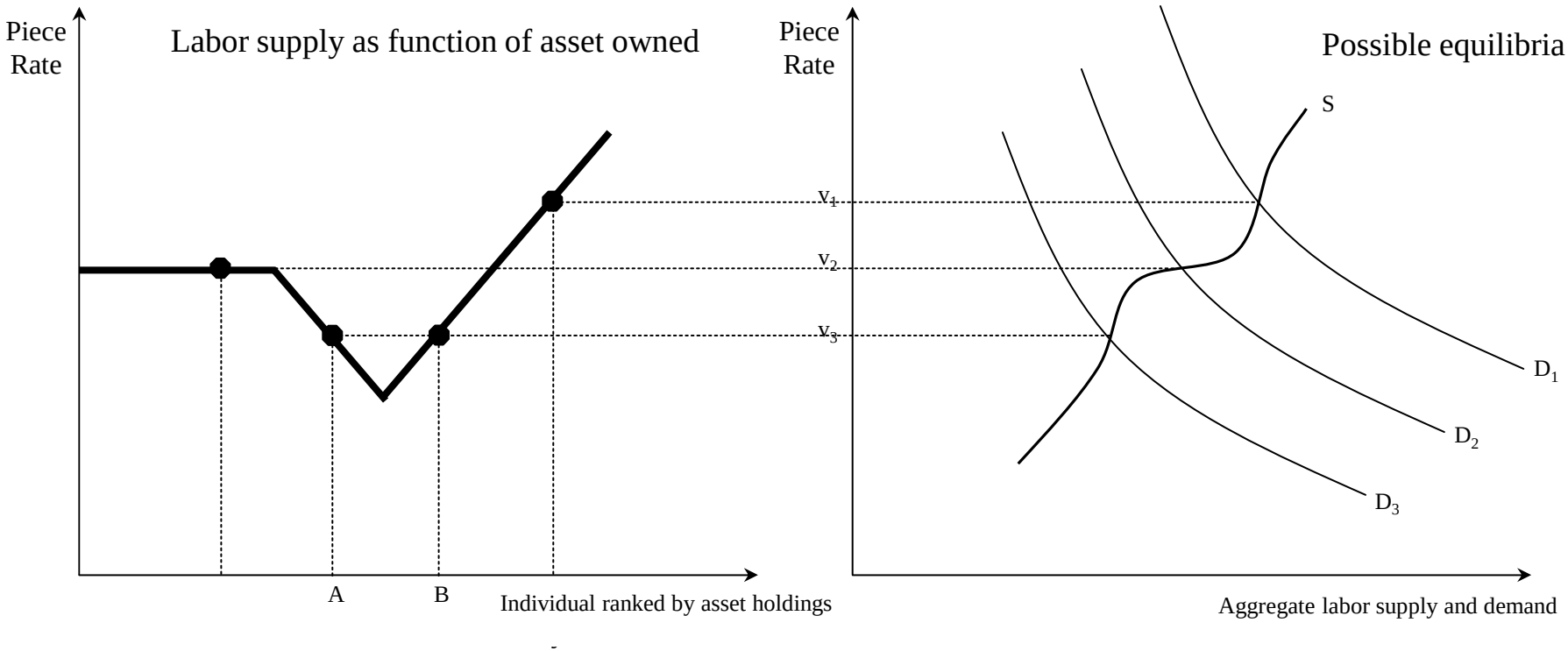
  Reservation wage that a person is willing to work increases with wealth

- Labor supply as a function of the two

  U-shape highlighted curve represents the minimum wage that individuals/households are willing and able to work

Model of Nutrition and Productivity (Dasgupta & Ray)

➢ **The effect of non-labor income on labor supply and market equilibrium**

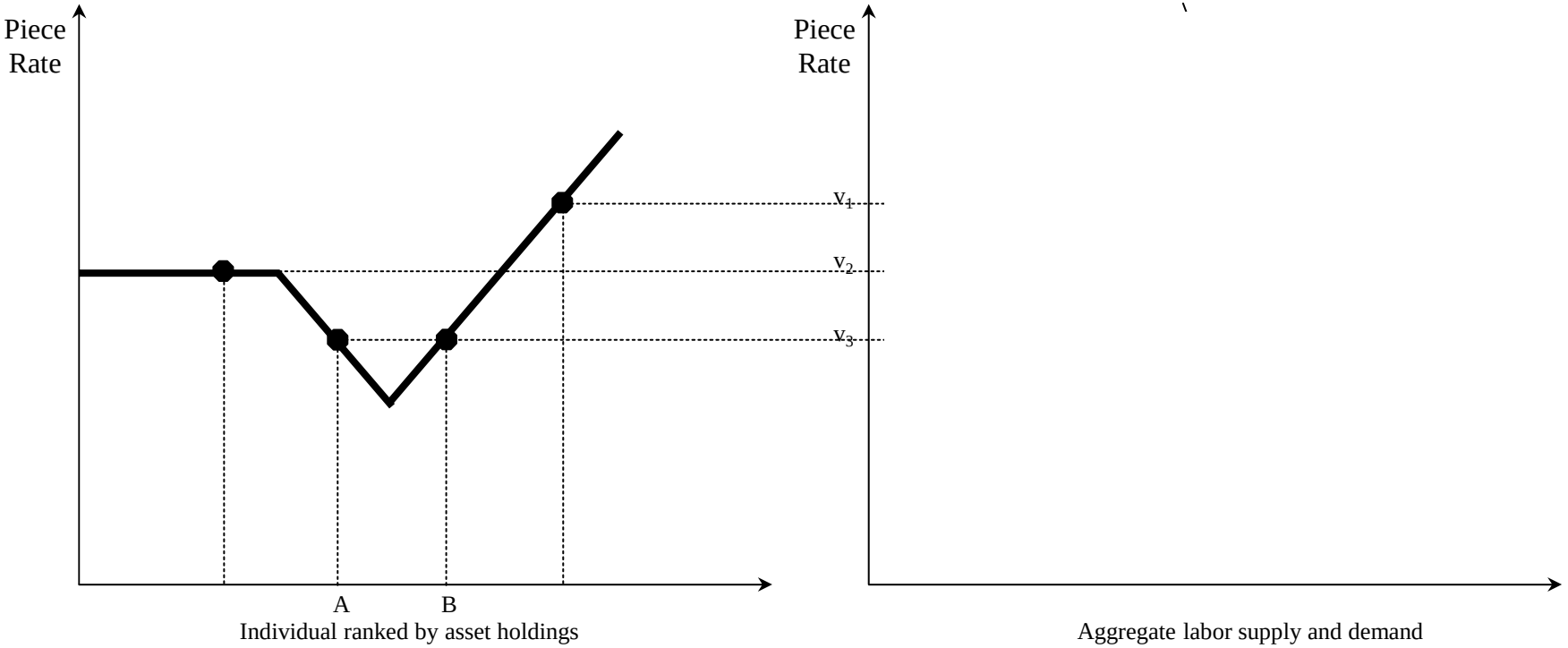


- For each piece rate, supply of labor is the amount worked by those whose minimum rate is below the on-going rate
- At small demand D_3, people to the left of A (with small wealth) are involuntary unemployed: the on going wage does not allow them to carry out sustained work without seriously impairing their nutrition and health!

Model of Nutrition and Productivity (Dasgupta & Ray)

- **The effect of wealth redistribution** (e.g., redistribute asset from those to the right of B to those left of A)

Let's draw this together!



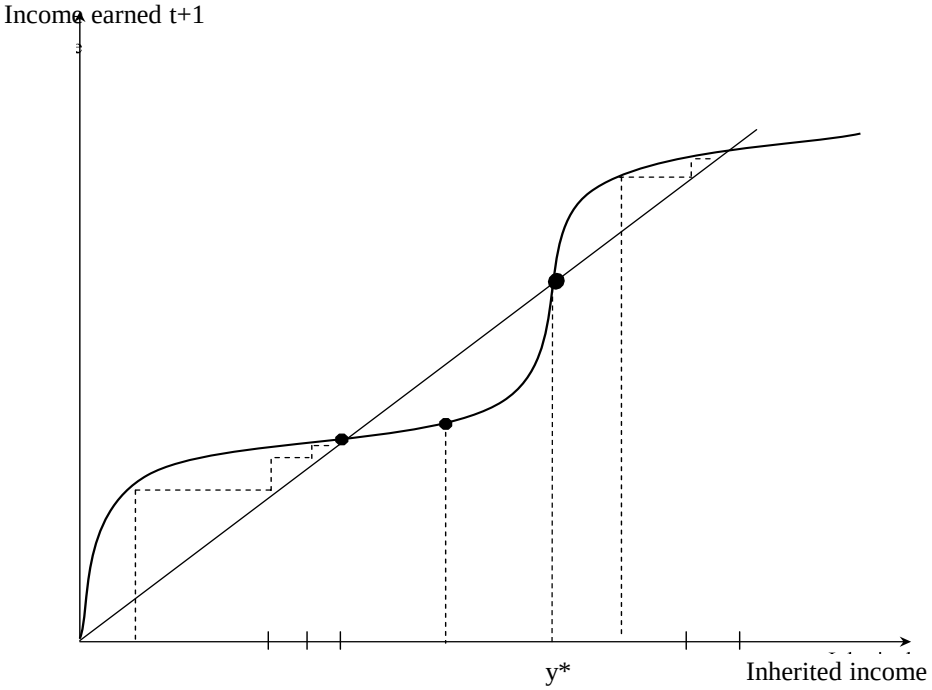
- Recipients are able to work at lower nutrition efficiency wage
- Losers of asset will be willing to work at lower wage
- Labor supply and total production increases in the new equilibrium!

What have we learned from this model?

- Income could have feedback effect on labor productivity through nutrition
  - Nutrition efficiency wage necessary to allow people to be able to work
  - Too low wage → low productivity → limit access labor market
- Non-labor income (wealth) → better nutrition → reduced nutrition efficiency wage
  - Labor market access increases with wealth → magnifying asset inequality
  - Potential crowd-in effect of asset and/or asset transfer programs on improved access to labor market mediated through nutrition-productivity channel
- Implications:
  - What if the poor could enter into long-term employment contracts?
  - What would be the effect of providing free meals?
  - What would be the effect of improved access to credit?

Nutrition-based poverty trap from capacity curve

- Suppose an individual eat in the morning, work and is paid a piece rate v by the end of the day, the wage of which determine what he eats the next day
  - Through nutrition (nt) we can write a dynamic function of income yt



- yt =v*work capacity = f(nt)

  nt = g(yt-1)

  yt = f(g(yt-1)

- Multiple equilibria emerge if capacity curve intersect 45-degree line from below at a threshold (f'(g(yt-1)>1)

  f'(g(yt-1) = f'()g'() = f'()*f*g'()*g

  = En,y*Ey,n >1

- This implies that nutrition-based poverty trap could emerge if the product of elasticities of nutrition wrt. income and income wrt. nutrition is greater than 1
- Empirically, we should thus expect large nutrition intake response to income and also large income/productivity response to improved nutrition!

Empirics of nutrition intake response to income

- What should we expect? → If there was a s-shape capacity curve, the poor should eat as much as they can, more so if nutrition-based poverty trap exist
  - For the poor whose food consumption already occupy majority of expenditure but are still currently undernourished, nutrition intake should response at least 1-to-1 to income

	As a Share of Total Consumption					% HHs with any Festival
	Food	Alcohol/ Tobacco	Education	Health	Festivals	Expenditure
Living on less than $1 a day						
Rural						
Cote d'Ivoire	64.4%	2.7%	5.8%	2.2%	1.3%	59.9%
Guatemala	65.9%	0.4%	0.1%	0.3%	0.1%	7.7%
India - Udaipur	56.0%	5.0%	1.6%	5.1%	14.1%	99.4%
Indonesia	66.1%	6.0%	6.3%	1.3%	2.2%	80.3%
Mexico	49.6%	8.1%	6.9%	0.0%	0.0%	2.7%
Nicaragua	57.3%	0.1%	2.3%	4.1%	0.0%	1.8%
Pakistan	67.3%	3.1%	3.4%	3.4%	2.4%	64.8%
Panama	67.8%		2.5%	4.0%	0.0%	0.0%
Papua New Guinea	78.2%	4.1%	1.8%	0.3%	1.5%	21.7%
Peru	71.8%	1.0%	1.9%	0.4%		
South Africa	71.5%	2.5%	0.8%	0.0%	3.2%	90.3%
Timor Leste	76.5%	0.0%	0.8%	0.9%	0.0%	49.0%

Sources: Banerjee and Duflo (2007)

Empirics of nutrition intake response to income

- **Elasticity of nutrition intake with respect to income**
  - Need to estimate ln ni = alnyi+bxi+ei

    where ni: nutrition intake per capita, yi: income or expenditure per capita
  - Why in ln? → En,y = dlnni/dlnyi = a at specific point (ni, yi)

What are issues to think about?

Empirics of nutrition intake response to income

- How do we measure nutrition intake per capita?
  - We can get detailed information from people about food consumed last month (or week) and use a calorie or nutrition conversion table to estimate how much calories/nutrition they represent
  - Can we use food expenditure per capita instead?

    food expenditure per cap = calories per cap * price per calorie

    ln (food expenditure per cap) = ln (calories per cap) + ln (price per calorie)

    So in the regression:

    ln foodexpenditure = ln(calories per cap)+ln(price per calorie) = a….

    - As p should co-move with expenditure per cap, how would this bias a?
    - $E_{foodexpenditure,y} = E_{y,n} + E_{y,p}$, so overstate the elasticity of nutrition wrt. Income due to changes in preference for taste, variety and quality

    → focus on nutrition intake not expenditure

Empirics of nutrition intake response to income

- Endogeneity issues in estimating …
  - Reverse causality (nutrition may affect income through productivity)
  - Omitted variable bias?
  - Measurement errors
    - How do we measure nutrition/calorie intake? → from food consumption
    - How do we construct expenditure? → take into account food consumption
    - Random measurement errors in food consumption can be transmitted by construction to both expenditure (y) and nutrition intake (x)
    - Bouis and Haddad: use other measure of nutrition intake that do not subject to the same error (e.g., direct measures) or use instrument for expenditure that is not related to nutrition intake (other components of expenditure not imputed from food consumption)

Empirics of nutrition intake response to income

- Functional form
  - We know that En,y is unlikely to be the same everywhere, this is in fact the basis for poverty trap
    - The Linear model estimate mean elasticity = ahat
  - Consider estimating non-linear relationship:

    ln nt = g(lnyi)+xbi_ei
    - How to interpret elasticity? → slope of the function at each point (yi,ni)
    - Parametric estimation: higher order polynomial (pro and con?)
    - Semi- or non-parametric estimations: kernel, localpolynomial, LOWESS, Spline regression etc. (easily recover non-linear relationship but could fail to control for heterogeneity)

    So are calories increasing very rapidly with income for the very poor?

Empirics of nutrition intake response to income

- **Income and nutrition relationship in India**
  - Subramanian and Deaton (1996) (smoothed local regression)

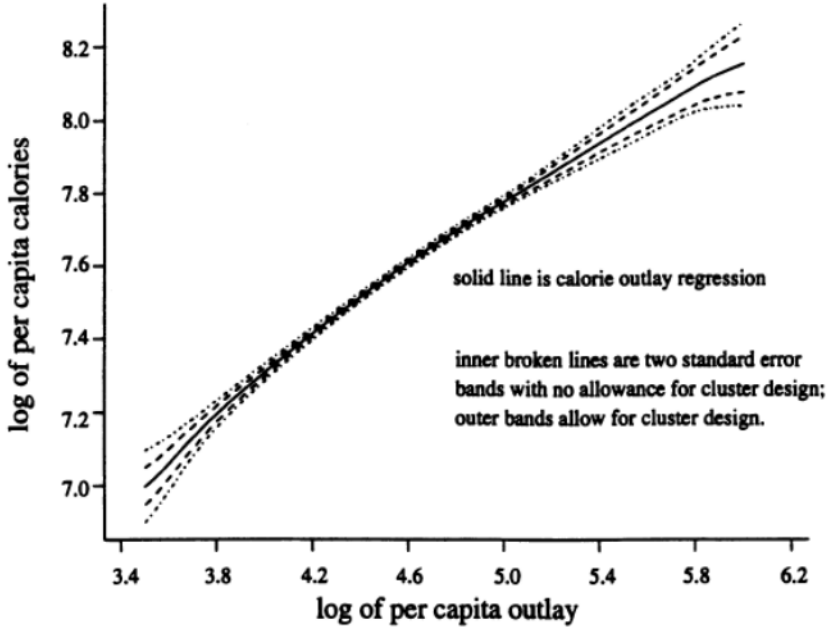


FIG. 2.—Regression function for log calories and log per capita expenditure, Maharashtra, India, 1983.

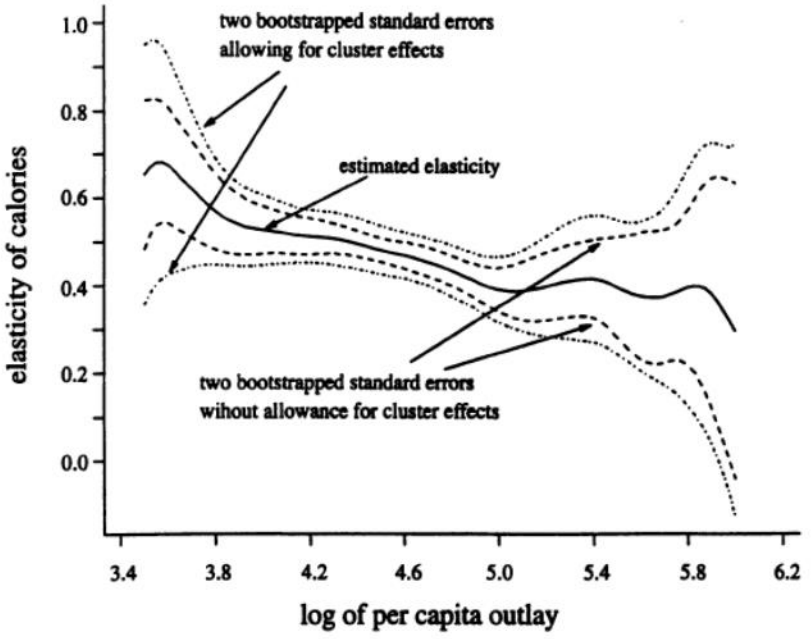


FIG. 3.—Elasticity of per capita calories to per capita expenditure, Maharashtra, India, 1983.

- More expenditure → better nutrition
- The estimated $E_{y,n}$ ranges from 0.3-0.6 (decline by income) and averaged at 0.45. How to interpret this? When total expenditure per cap increase by 1%, the consumption of calories increase by 0.35% (less than 1 to 1)

Empirics of nutrition intake response to income

- **Income and nutrition relationship in India**
  - Subramanian and Deaton (1996) (smoothed local regression)

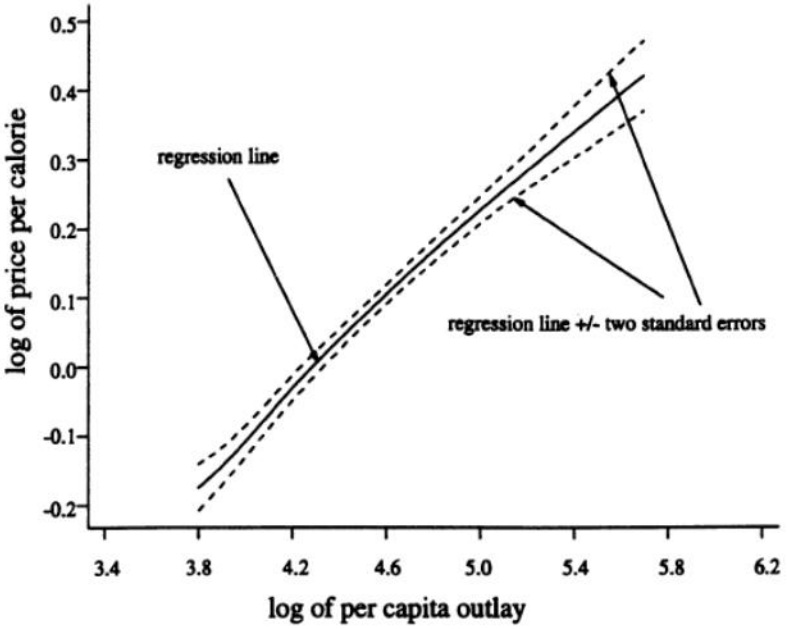


FIG. 4.—Log of price per calorie and log of per capita expenditure, Maharashtra, India, 1983.

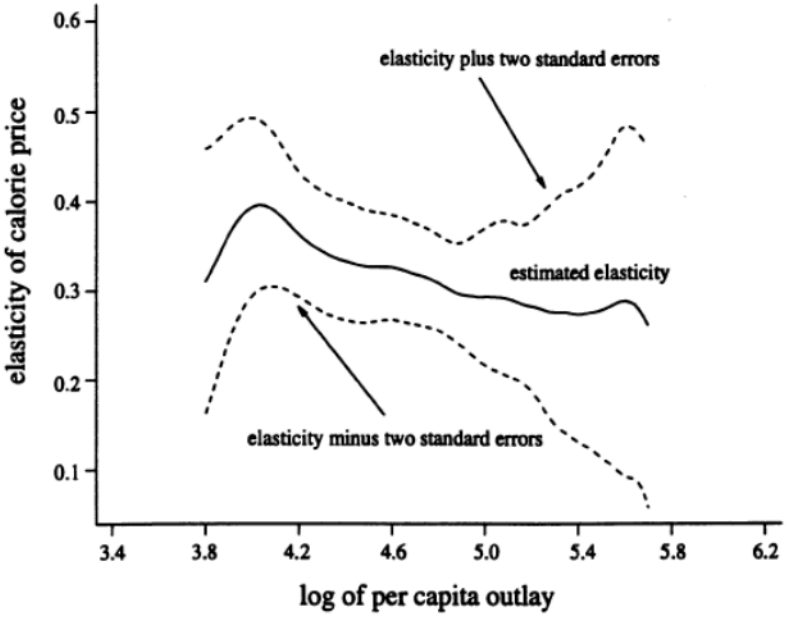


FIG. 5.—Elasticity of calorie price with respect to per capita expenditure, Maharashtra, India, 1983.

- When income increases, people spend more on expensive calories (meat instead of cereals) → $E_{p,y}$ averaged at 0.35, slightly higher for the very poor
- Even among the very poor, increase in economic well-being has a positive but not huge impact on calories consumed!

Empirics of nutrition intake response to income

- **Income and nutrition relationship in India**
  - Subramanian and Deaton (1996) (OLS regression)

OLS Estimates of Double Log Calorie and Calorie Price Regressions with Other Covariates

	Log Calorie Availability				Log Price per Calorie			
	All Data (1)		Within Village (2)		All Data (3)		Within Village (4)	
	β	|t|	β	|t|	β	|t|	β	|t|
Constant	6.028	(78)			−1.5934	(18)		
ln PCE	.3655	(29)	.3407	(27)	.3799	(25)	.3217	(23)
ln household size	−.1572	(14)	−.1630	(21)	.0839	(6.8)	.0661	(8.4)
rm04	−.0967	(2.2)	−.1461	(4.1)	.1024	(2.3)	.1008	(3.3)
rm59	.0488	(1.2)	.0321	(1.0)	−.0467	(1.2)	−.0331	(1.2)
rm1014	.0891	(1.9)	.0612	(1.9)	−.1120	(2.3)	−.0842	(2.9)
rm1555	.1636	(5.1)	.1634	(5.9)	−.1700	(4.3)	−.1347	(5.0)
rm55+	.1406	(3.0)	.1213	(2.8)	−.1565	(3.6)	−.1074	(2.9)
rf04	−.1359	(3.1)	−.1869	(4.9)	.0460	(1.1)	.0742	(2.2)
rf59	.0176	(.4)	−.0040	(.1)	−.0643	(1.4)	−.0476	(1.4)
rf1014	.1140	(2.8)	.0679	(2.0)	−.1108	(2.7)	−.0873	(3.0)
rf1555	.0420	(1.6)	.0514	(2.1)	.0085	(.3)	−.0021	(.1)
Scheduled caste	−.0083	(.8)	−.0179	(2.0)	.0020	(.2)	−.0071	(.8)
Hindu	.0114	(.7)	.0302	(2.1)	−.0562	(2.6)	−.0605	(4.4)
Buddhist	.0237	(1.1)	.0400	(2.0)	−.1080	(4.0)	−.0760	(4.0)
Self-employed nonagriculture	.0187	(1.0)	.0064	(.4)	−.0270	(1.1)	.0079	(.5)
Agricultural labor	.0433	(2.2)	.0222	(1.4)	−.0837	(3.4)	−.0418	(2.7)
Nonagricultural labor	.0275	(1.1)	.0293	(1.5)	−.0210	(.8)	−.0315	(1.7)
Self-employed agriculture	.0618	(3.5)	.0389	(2.7)	−.0610	(2.8)	−.0118	(.8)
R^2	.5532		.6706		.4254		.6414	

- Estimated mean $E_{n,y}$ at 0.37!

Empirics of nutrition intake response to income

- **Income and nutrition relationship in India**

How can we reconcile these parametric and non-parametric results?

So the resulting $E_{n,y}$ which is a lot lower than 1 is already over-estimated!

Empirics of nutrition intake response to income

- **Income and nutrition relationship in India**
  - Deaton and Dreze (2009) explores the evolution of income-calorie relationship (Engel curve) over time

Figure 1: Calorie Engel Curves, Rural and Urban India (1983 to 2004-05)

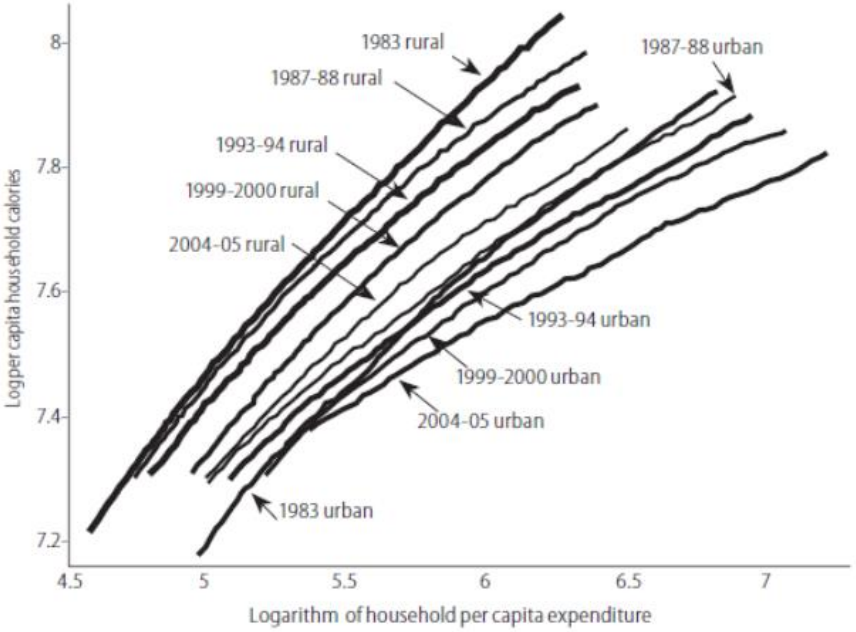
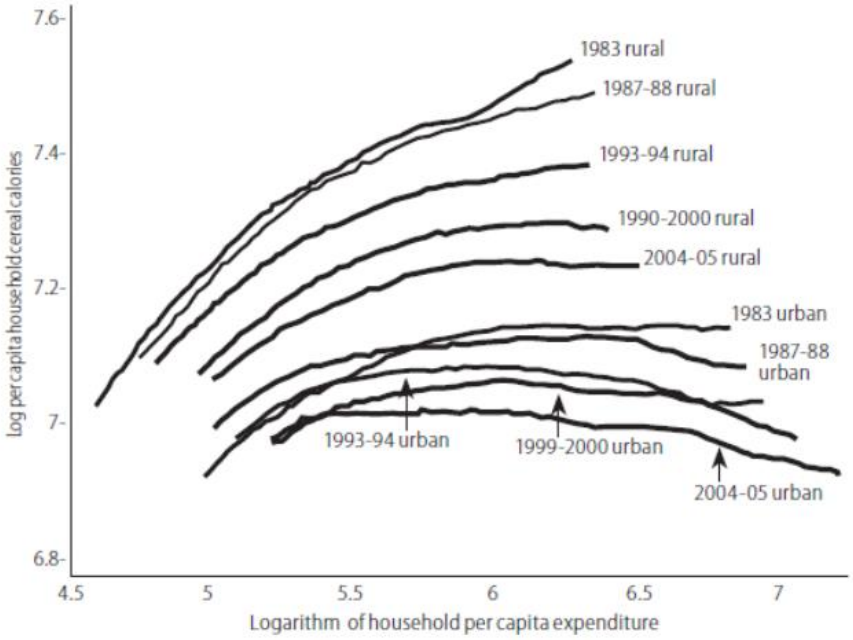


Figure 2: Cereal Calorie Engel Curves, Rural and Urban India (1983 to 2004-05)



- With economic growth, households move up the Engel curve, but the Engel curve (nutrition intake response to expenditure) fall over time

Empirics of nutrition intake response to income

- **Income and nutrition relationship in India**
  - On balance, the consumption of calories and all other nutrients has fallen in India over the last 25 years despite persistently high undernutrition!

Fractions of the Population Living in Households with per Capita Calorie Consumption below 2,100 Urban and 2,400 Rural

Year	Round	Rural	Urban	All India
1983	38	66.1	60.5	64.8
1987-8	43	65.9	57.1	63.9
1993-4	50	71.1	58.1	67.8
1999-0	55	74.2	58.2	70.1
2004-5	61	79.8	63.9	75.8

Source: *Authors' calculations based on NSS data.*

Sources: Banerjee and Duflo (2007)

Empirics of nutrition intake response to income

- **What have we learned from existing evidence in India?**
  - Overall, there is positive and sizable nutrition intake response to income (estimated mean of 0.3-0.45), but nowhere closed to 1 even the poorest
  - This may even be overstated since results are from comparing different households, not the same households as we give them more money → various endogeneity issues:
    - Those who eat more → more productive and income (reverse causality)
    - Those high income may have different tastes (and many other things?) and so may eat differently the low income (omitted variable bias)
  - Jensen and Miller experiment further suggests that the income effect on calories may even be negative for some subgroup (Giffen behavior)
  - The (malnourished) poor do not seem very eager for extra calories, why?
    - Even the very poorest could also value taste, variety, quality of food?
    - May be they do not need to eat as much (changing livelihood, jobs)
    - The effect of calories on productivity is low to start with?

Empirics of productivity response to nutrition

- **Elasticity of productivity with respect to nutrition**
  - Need to estimate ln yi = alnni+bxi+ei

    where ni: nutrition intake per capita, yi: income or expenditure per capita
  - Pretty much similar identification issues with the former case!
    - Reverse causality, measurement errors, omitted variable bias, etc.
- Strauss (1986) studied the effect of calorie consumed on labor productivity in farming communities in Sierra Leone
  - Using food price as instrument for calories consumed
  - He found an elasticity of 0.34 and 0.49 for the poorest
  - But can we think of other potentials when the nexus between nutrition (human capital) and income can lead to a vicious circle of poverty trap??

Empirics of productivity response to nutrition

- **Productivity response to improved nutrition intake**
  - Need to estimate ln yi = alnni+bxi+ei

    where ni: nutrition intake per capita, yi: income or expenditure per capita
  - Pretty much similar identification issues with the former case!
    - Reverse causality, measurement errors, omitted variable bias, etc.
- Strauss (1986) studied the effect of calorie consumed on labor productivity in farming communities in Sierra Leone
  - He estimates the above relationship using food price as instrument for calories consumed
  - He found the estimated elasticity of 0.34 on average and highest (0.4) for the poorest

Empirics of nutrition intake response to income

- **Productivity response to calorie consumption in Sirrera Leone**
  - Strauss (1986)

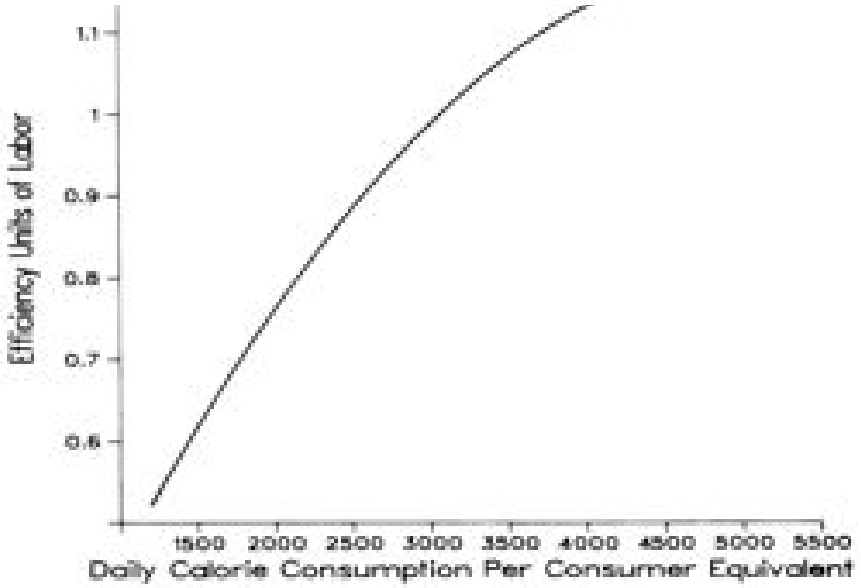


FIG. 2.—Estimated efficiency labor function

sumption per consumer equivalent $h(\cdot)$ rises much more steeply. At an intake of 1,500 calories the calorie elasticity is .75. The level of $h(\cdot)$

  - Calories makes people more productive.
  - Estimated elasticity (slope) highest for the poorest → when calorie consumption increase by 1%, their productivity increase by 0.4%

- **Can we think of other potentials when improved nutrition could have larger impacts on productivity?**

Empirics of nutrition intake response to income

- **Productivity response to micronutrient**
  - Apart from calorie deficiency, there are other forms of undernutrition. The critical ones are “hidden hunger” or micronutrient deficiency
  - Thomas et al. (2004) conducted experiment in Indonesia by providing iron supplement to randomly selected households.
    - People who were anemic at baseline were less likely to be anemic at endline, worked longer hours and earned more money if they got supplement comparing to placebo
    - Self-employed workers getting supplement also have $40 increase in yearly earning relative to those getting placebo and the fortified fish source cost $6 per year → clearly the productivity response to this iron supplement is well above 1-to-1!

Empirics of nutrition intake response to income

- **Childhood development and productivity**
  - Nutrition during childhood is likely a long-term investment
  - Small improvement in nutrition could have large long-term impact on adult wages and for the entire life for at least two reasons:
    - Long-term effect through education: children may learn better if they are well nourished
    - Long-term impact on health: irreversible losses of poor nutrition during childhood or in utero.

  → The elasticity of life-time earning with respect to improvement of childhood nutrition may be much larger than 1!

  - Miguel and Kremer (2004) found that a school based deworming program that cost $0.49 would increase life time earning of affected children by $30. Hence, the elasticity is much greater than 1 in this case!

Conclusions and Policy Implications

- A classic model of Dasgupta and Ray has not been able to describe reality especially with respect to calories-income relationship. But there are good potentials in other settings, e.g., early childhood nutrition – life-time income
- Why the poor are not eager for more nutrition? Economists hypothesise
  - The role of labor market: perhaps people do not really benefit from increasing productivity (e.g., if they don't work for piece rate), people thus might have no incentive to consume more nutrients
  - The role of information: People might now realise the benefit of nutrition
  - The role of consumer choices: preference for taste, quality and variety
- Given these results, policy intervention thus
  - Enhance direct provision of calories or nutrients (potentially disappointing impacts on cash transfer, price subsidies (as we will see in tutorial)
  - Targeted micro-nutrient →policies that focus on quantity of food may be misguided in terms of the benefits they may bring (iron vs. free grain)
  - Targeted childhood improvement through feeding children and pregnant
  - Consider household's utility maximisation: match nutrients with preference