Daylight Developers
(and the Inexorable Rise of the Chess Block)

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this paper

microeconomics of urban daylight

- make explicit shadow of city's building envelope
- explain urban design, industry organization, house prices
- welfare: first part here (second part: Dascher/Haupt (2024))

global "trends"

real estate

- developers fewer, larger (Quintero (2023), Kwon et al. (2024))
- houses dearer (. . .)
- blocks more regular (. . .)

global “trends”

labor

- we spend less time at work
- we spend more time at home
- we value daylight more

a theory of long-run changes

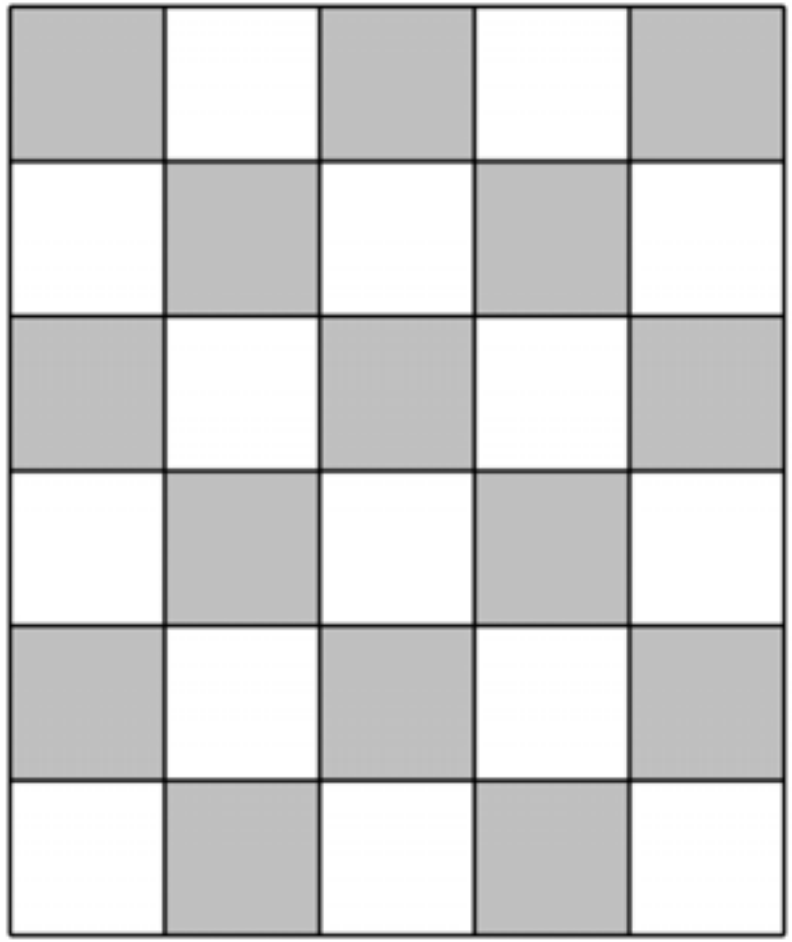
. . . in block design, real estate industry, and house prices

- we spend less time at work
- we spend more time at home
- we value daylight more

- chess block becomes more profitable
- developers consolidate
- which pushes marginal resident out

chess block

an example



chess block I

1920's radiant city (Paris)

chess block II

1950's Stuyvesant Town (New York)

chess block III

2020's Dortmund

chess block IV/component house

2020's Berlin

behold (there are many alternatives)

1850's Paris

bd. Magenta

1870's Paris

model

a little notation

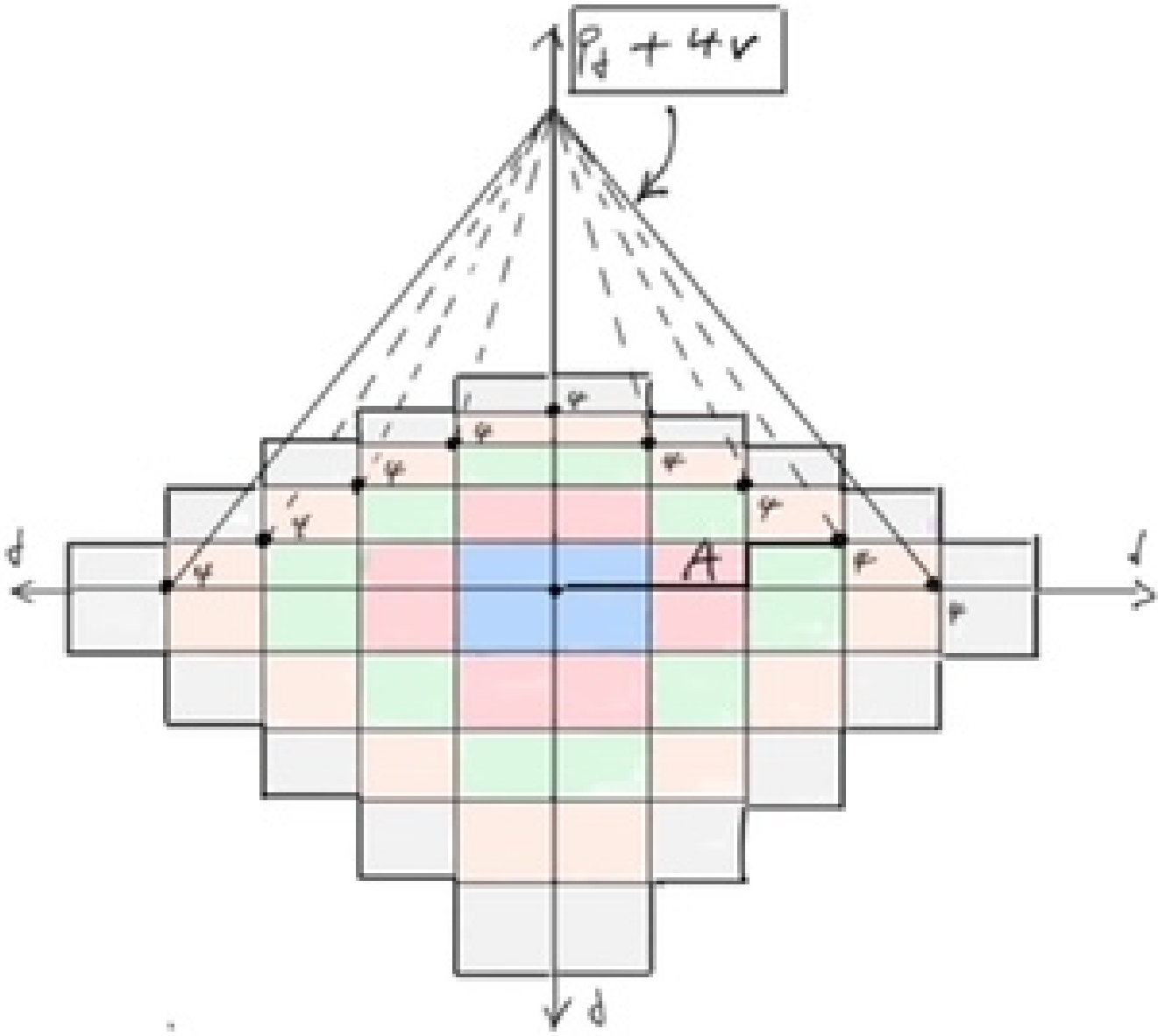
- single storey for now
- each house 4 windows (steel frame)

- daylit window is valued at $v > 0$
- location rent at distance δ: $p_\delta < 0$

- N: total number of houses on the block
- Λ: total number of daylit windows on the block

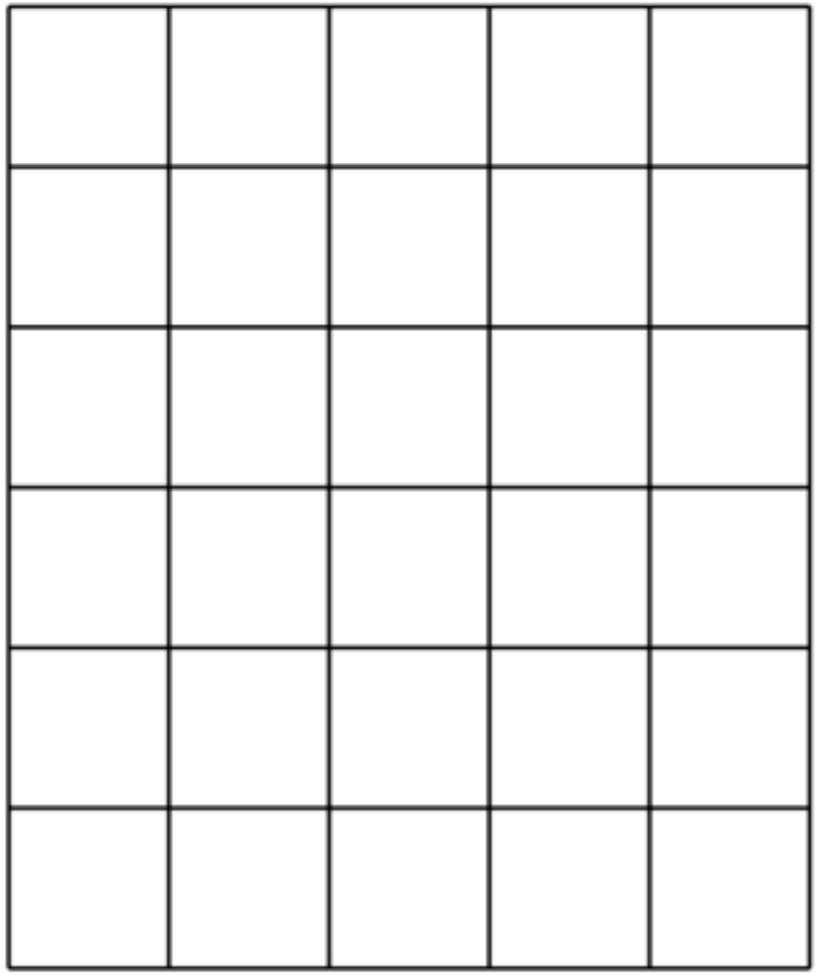
- $\boldsymbol{x}$: block design

closed – daylit – city



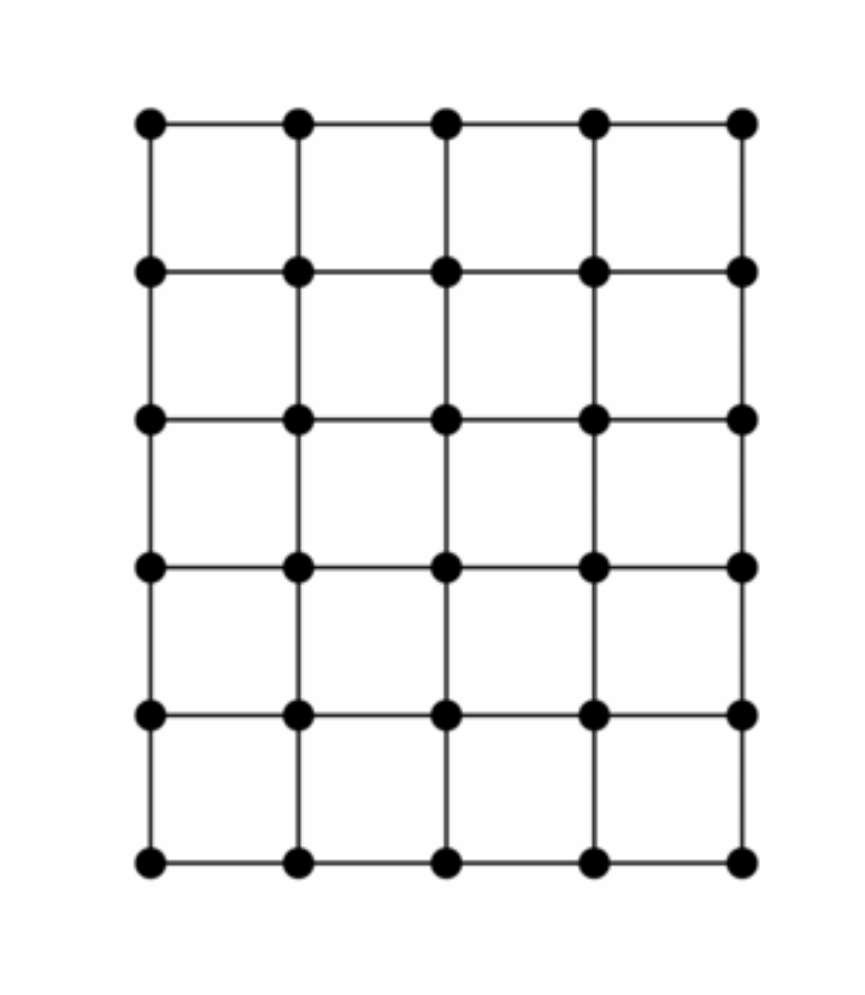
block

lots, street, streetfront, adjacencies



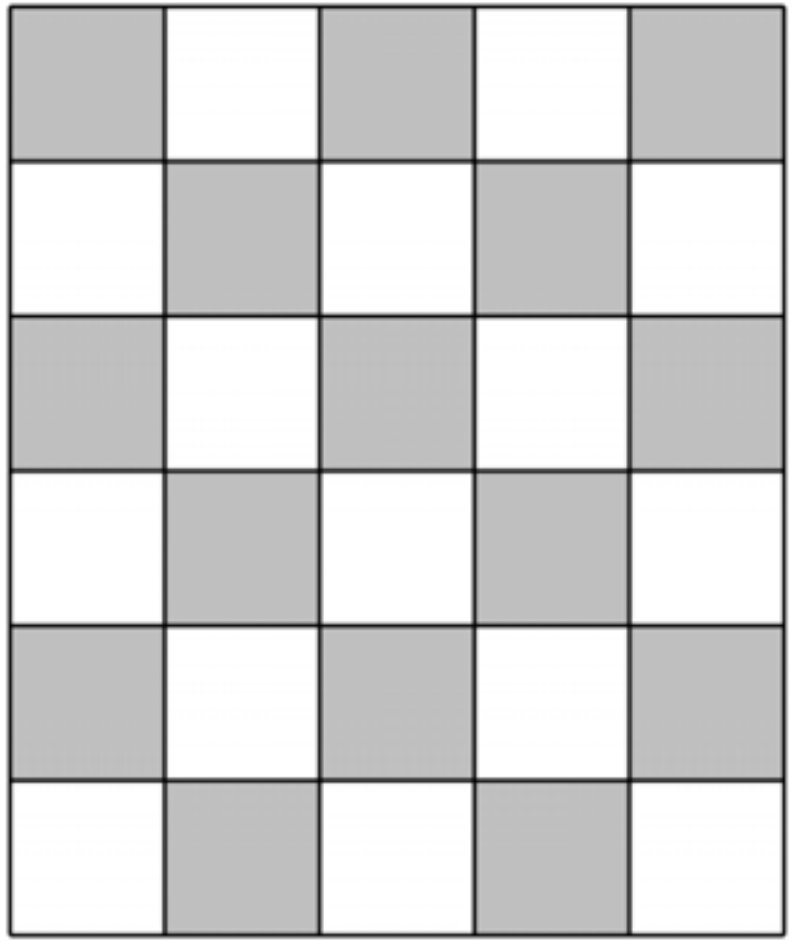
grid graph

edges emphasize adjacencies



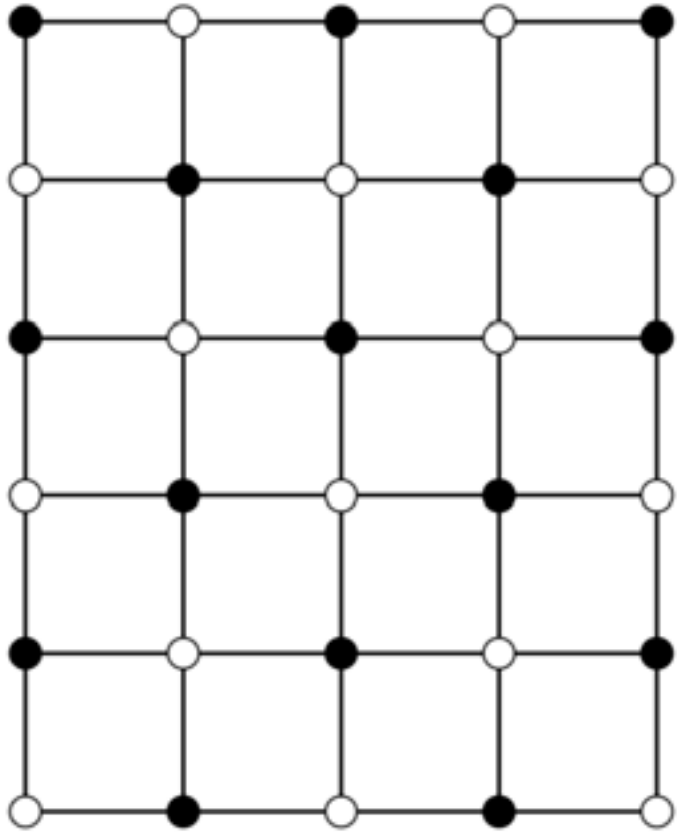
chess block

houses (in grey) and yards (in white)



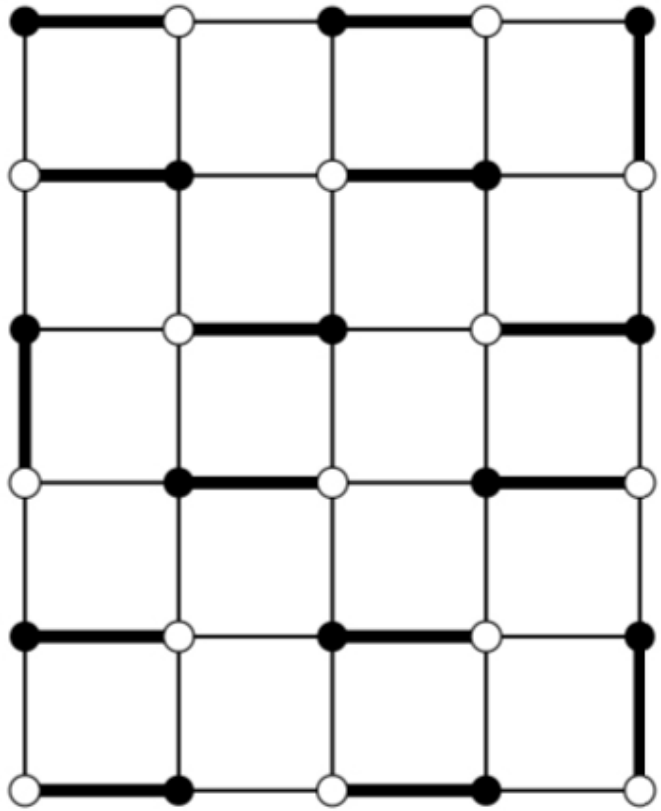
chess block

houses (vertices in black) and yards (vertices in white)



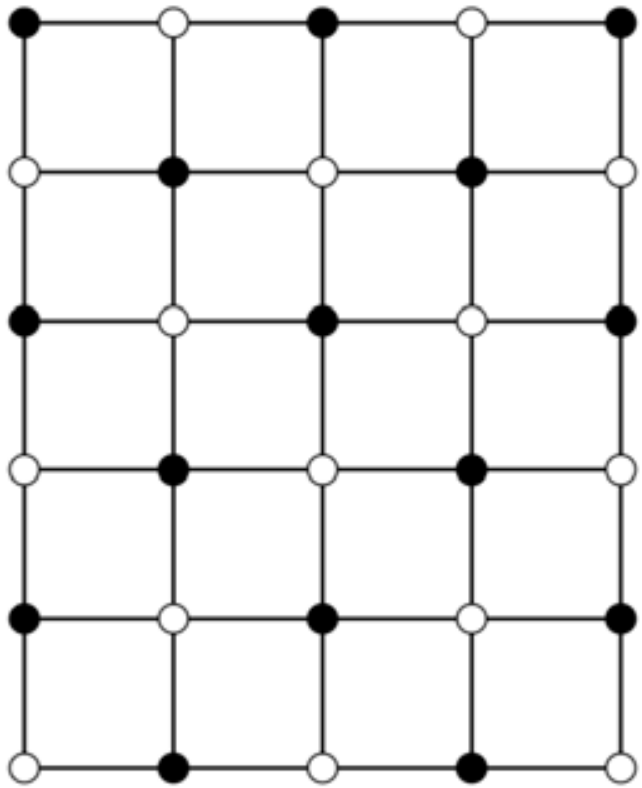
$\max_x$ daylit houses

15 matches form a "matching" (no two matches share a vertex)



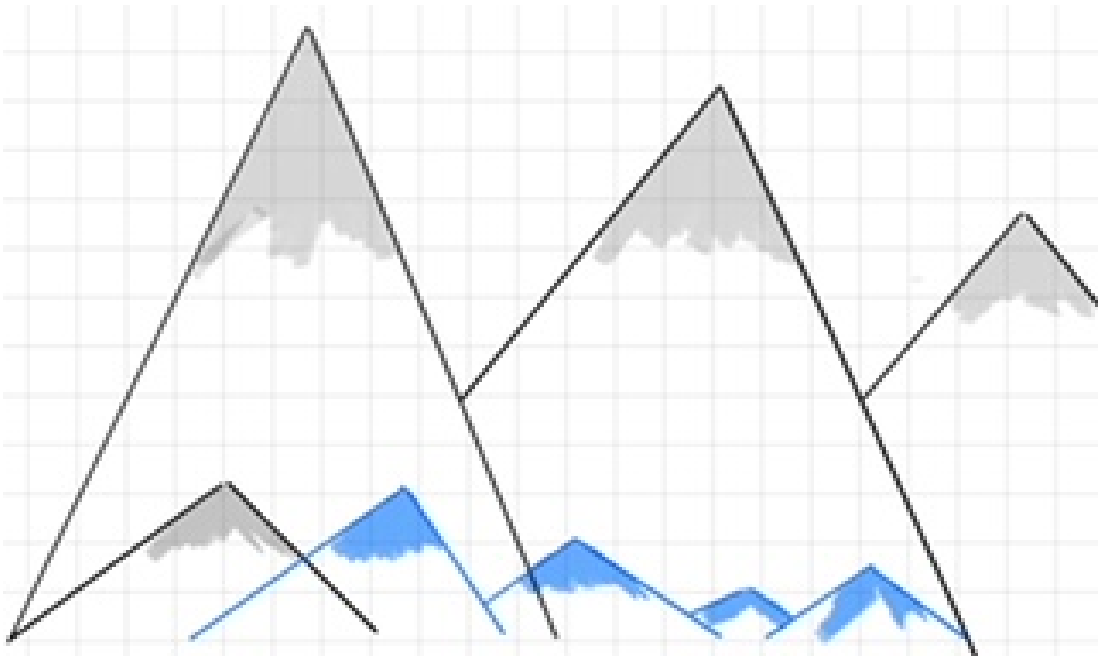
$\max_x$ daylit houses

15 yards form a "cover" (every edge taps into a yard)



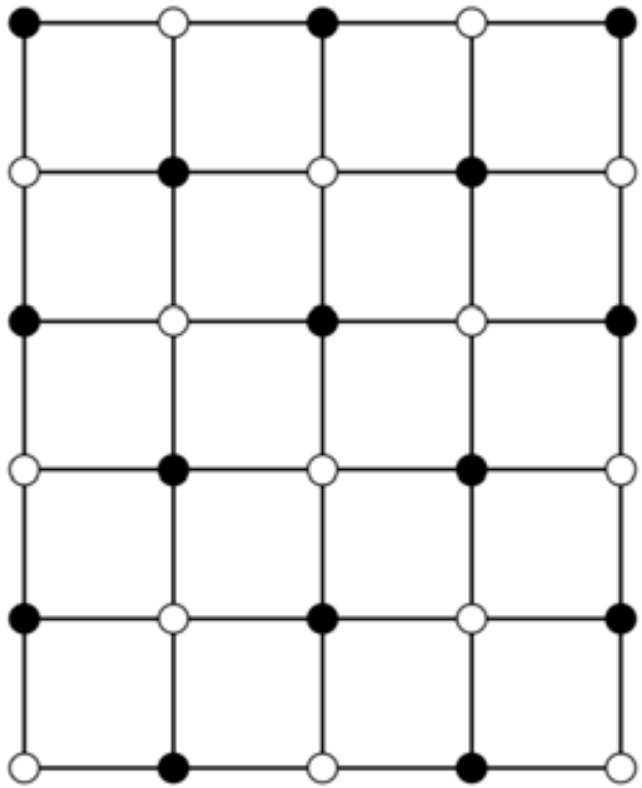
$\max_x$ daylit houses

weak duality (Alps vs. Himalayans)



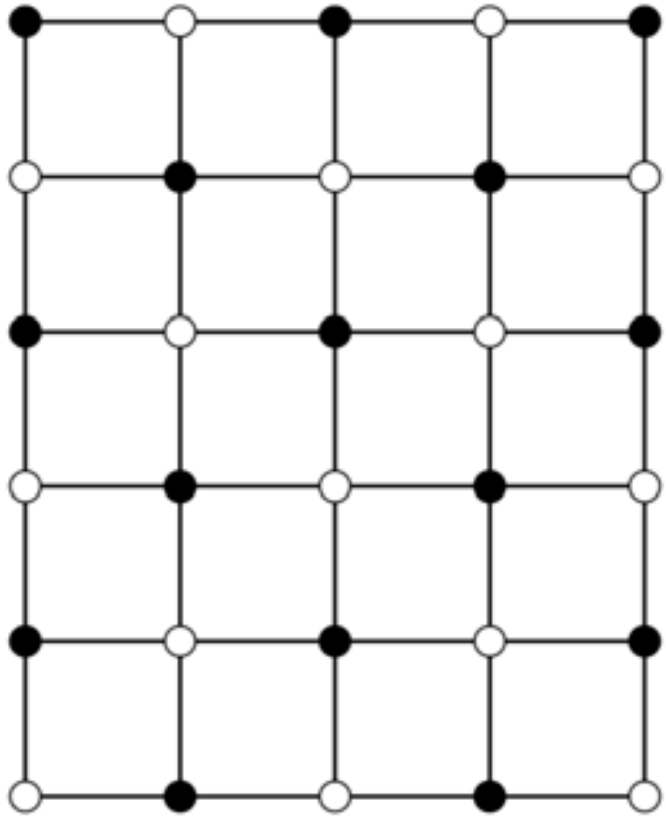
$\max_x$ daylit houses

cover is minimum ($= 15$), daylit houses are maximum ($= 15$)



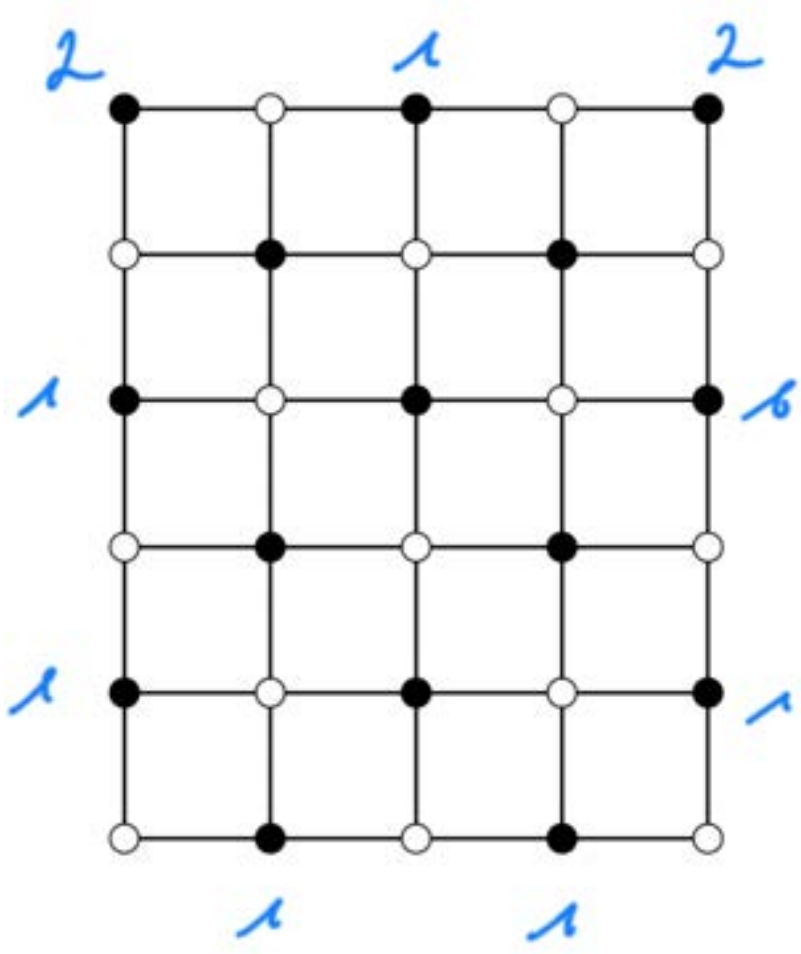
$\max_x$ – internally – daylit windows

each edge is a daylighting ($\Lambda_i = \varepsilon = 49$)



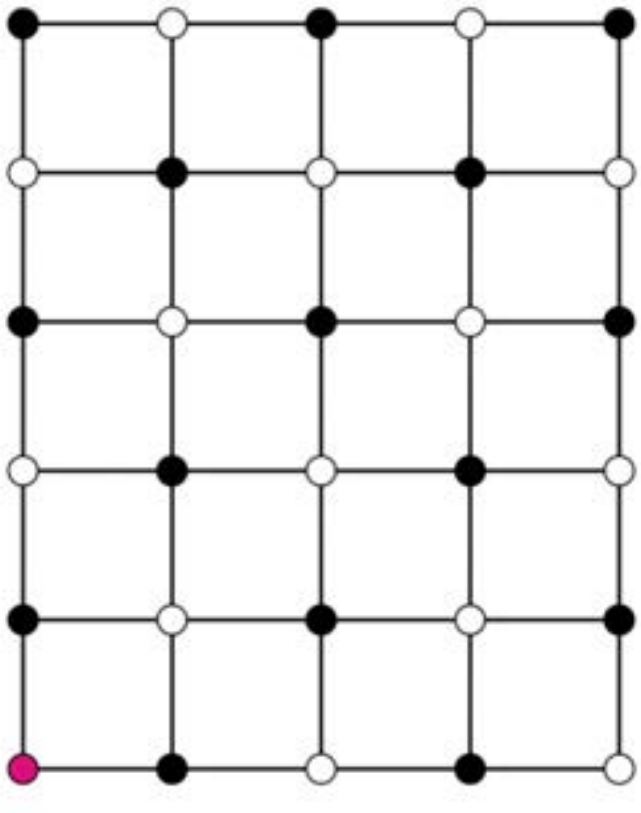
$\max_x$ daylit windows

$\Lambda_i = 49$, $\Lambda_o = 11$



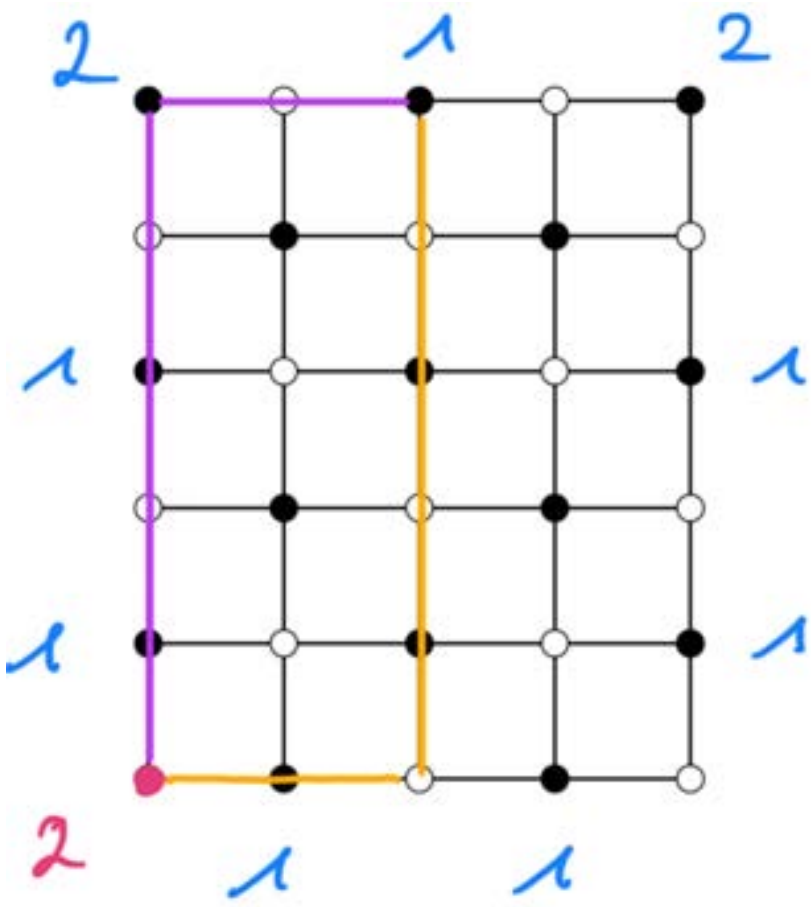
$\max_x$ daylit windows

increase Λ_o further? . . . but that destroys yard cover



$\max_x$ daylit windows

Λ_i falls by at least 2 bc there are at least 2 paths . . .



$\max_N$ block profit

block developer

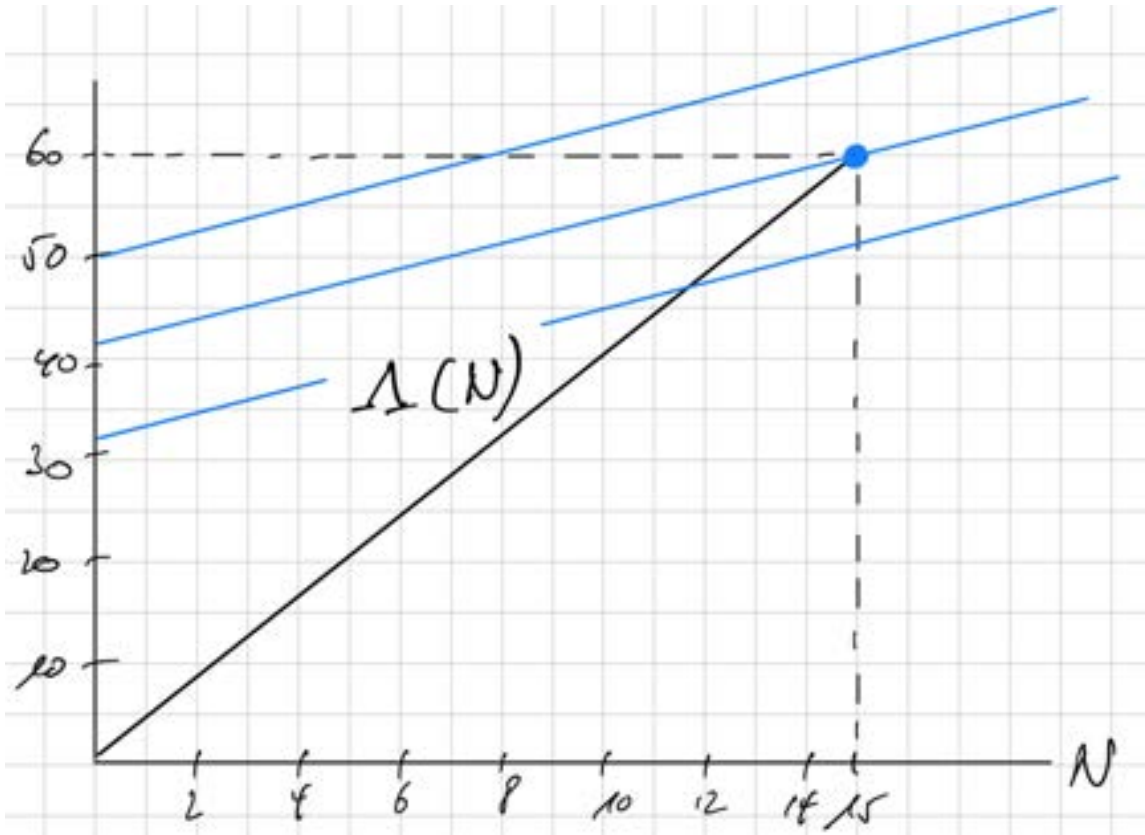
- first derive daylight frontier, $\Lambda(N)$,
- then maximize

$$\max_{x} \quad \Pi \;=\; pN \;+\; v\Lambda \quad \text{s.t.} \quad \Lambda(N)$$

- compare slopes of frontier and contour set (4 vs. $-p/v$)

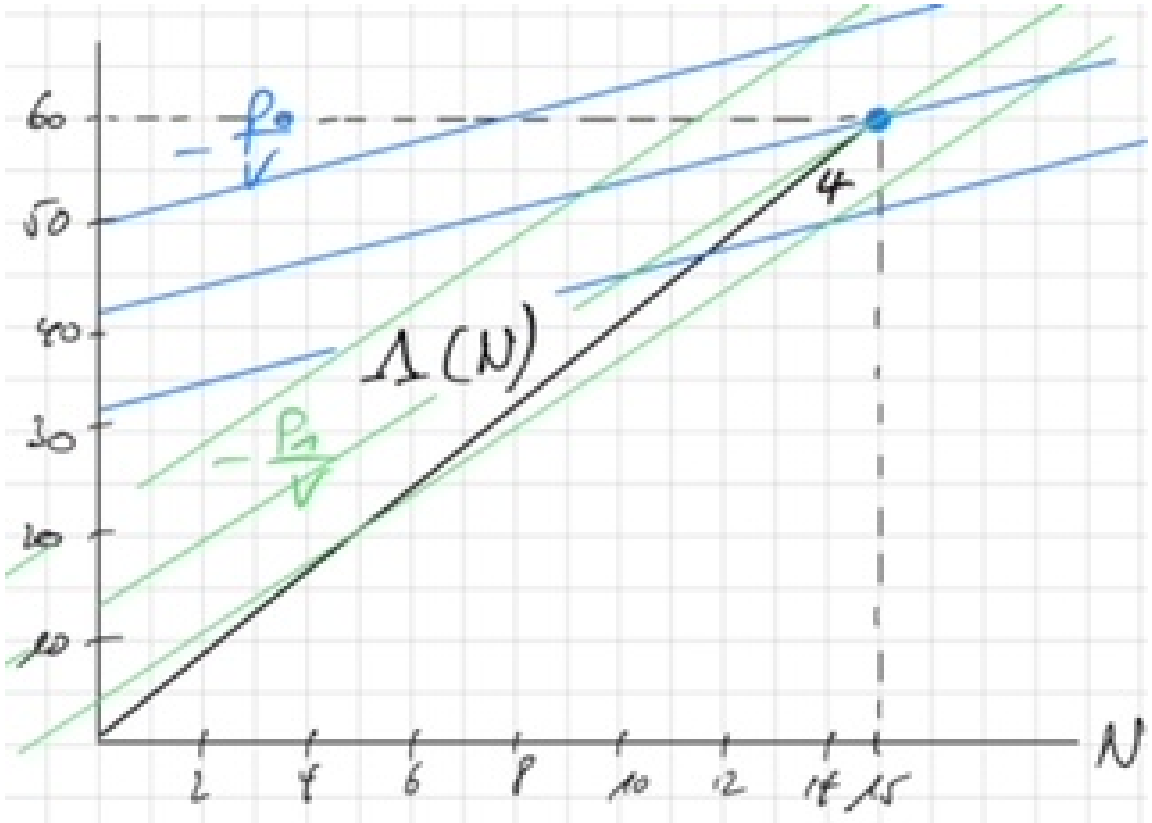
$\max_N$ block profit

Profit contours select chess block on daylight frontier $\Lambda(N)$



max_N block profit

Optimum design is chess block. Is invariant to location.



chess block

summary of properties (part even virtues)

- maximizes daylit houses
- maximizes daylit windows
- maximizes block profit (bc. resolves daylight externalities)
- ubiquitous
- cool within-block yard space
- maximum value function:

$$\Pi(p, v) = max_{\boldsymbol{x}} \Pi(\boldsymbol{x}, p, v) \tag{1}$$

sub-developer builds sub-chess block

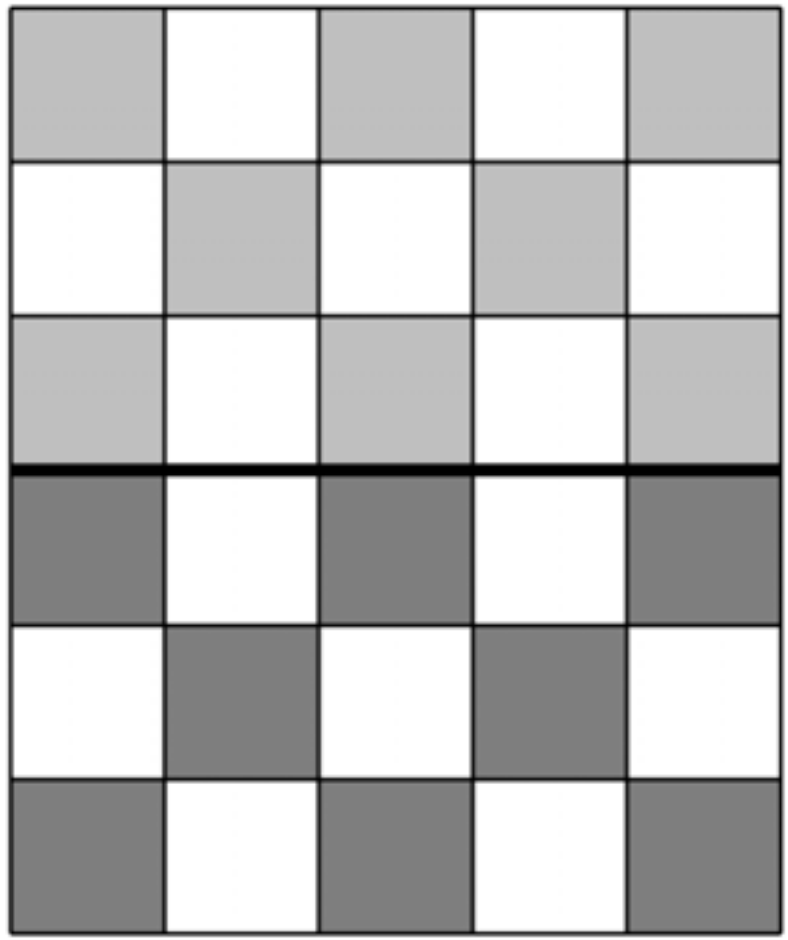
all properties generalize if sub-block is rect. and at least 2×2

- maximizes daylit houses on the sub-block
- maximizes internally daylit windows on the sub-block
- maximizes daylit windows on the sub-block
- maximizes block profit on the sub-block
- Maximum sub-developer value function:

$$\pi_s(p, v) = max_{\boldsymbol{x_s}} \pi(\boldsymbol{x_s}, p, v) \tag{2}$$

two subchess-blocks make no chess-block

Nash-equilibrium (if $-p/v < 1$)



Industry consolidation

daylight another reason for profit superadditivity

$$\sum_s \pi_s(p, v) \leqslant \Pi(p, v)$$

daylight is valued more

real estate/construction industry organization

- subdeveloper profit rises: $\partial \pi_s / \partial v = \Lambda_s$ (envelope theorem)
- block developer profit rises: $\partial \Pi / \partial v = \Lambda$ (envelope theorem)
- block developer profit rises by more, in response to $\Delta v > 0$:

$$\frac{\partial \Pi(p, v)}{\partial v} = \boxed{\Lambda(p, v) \geqslant \sum_s \Lambda_s(p, v)} = \sum_s \frac{\partial \Pi_s(p, v)}{\partial v}.$$

- more industry consolidation

daylight is valued more

urban design

- more and more blocks are developed by a single developer
- chess block design proliferates
- alternative designs all but disappear

daylight is valued more

house price

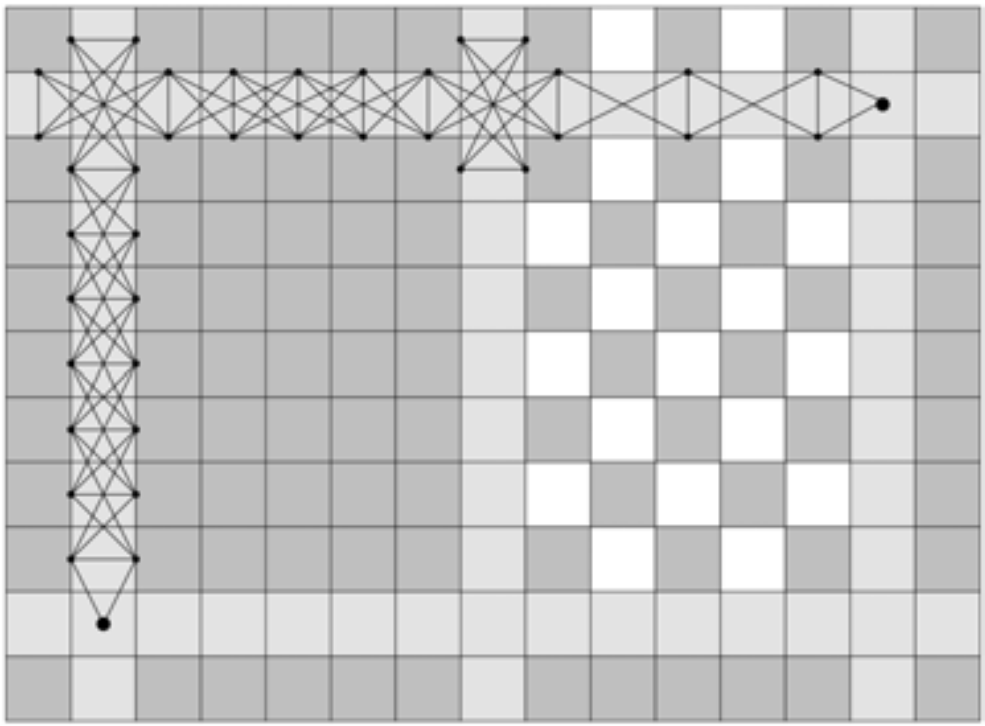
- chess block is less dense
- marginal resident lives further out
- house prices $p + 4v$ rise for all city residents (Ricardo)

Summary

- zoning-free house price increase
- ubiquity of chess block
- welfare?

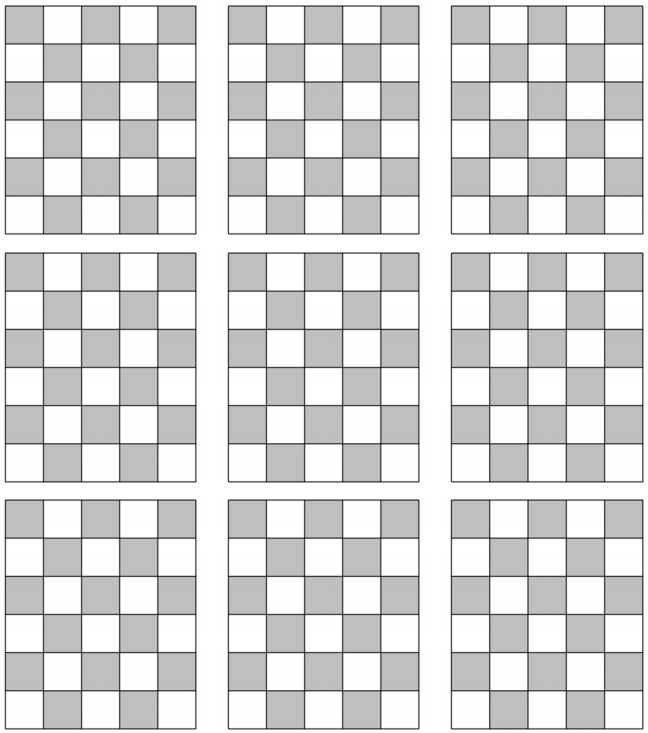
eyes on the street, urban retail

safety? (Dascher/Haupt (2024))



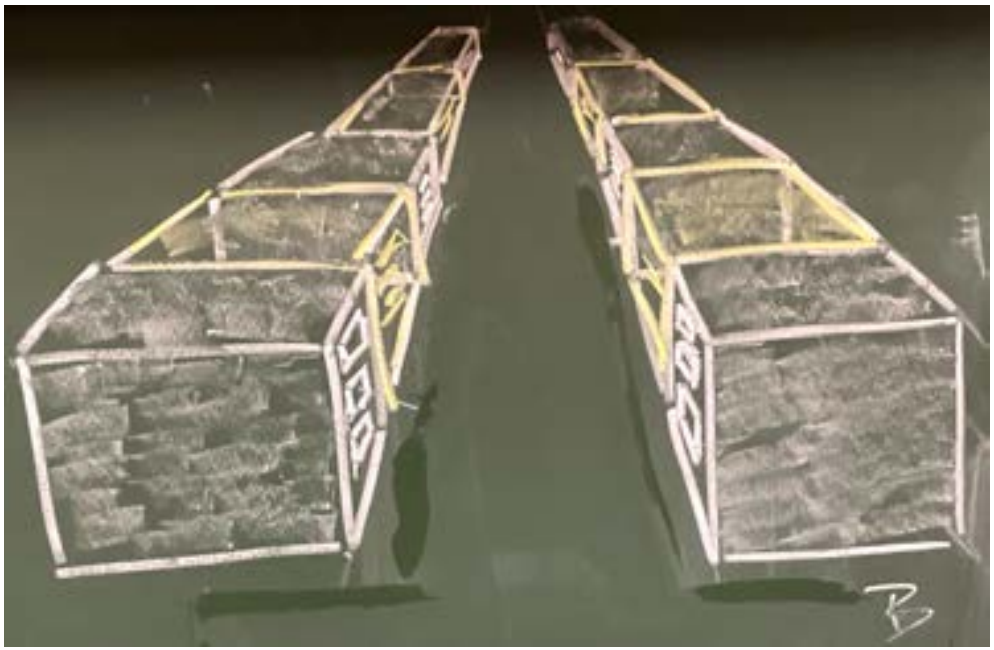
urbanity

orientation



global warming

what if shadow is valued more?



global warming

no shadow where needed most