Hedonic pricing (1)

Applied Econometrics for Spatial Economics

Hans Koster
Professor of Urban Economics and Real Estate

1. Introduction

- Yesterday:
  1. Spatial econometrics
  2. Discrete choice
  3. Identification

- Today:
  4. Hedonic pricing
  5. Quantitative spatial economics

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1. Introduction

- Yesterday:
  1. Spatial econometrics
  2. Discrete choice
  3. Identification

- Today:
  4. Hedonic pricing
     - Theory and estimation
  5. Quantitative spatial economics

1. Introduction

INDEPENDENT

Property

Olympic Park house prices have jumped 60 per cent

Average house price in the 14 areas of East London closest to the Olympic Park is now £334,1

Alex Johnson | @shedworking | Friday 25 July 2014 11:13 BST | 0 comments

5 shares

The Guardian

How a landfill site can hit the value of your home

Two hundred thousand homes close to landfill sites are worth an average £5,500 less because of the nuisance caused by dust, noise, smell and vermin, according to a government report.

In the first comprehensive look at the effect of landfill sites on house prices, the survey found that in the country as a whole prices were 7% lower near landfill sites. But there were marked regional variations, with the Scots losing 41% of the value of their homes if there was a landfill site within a quarter of a mile.

The value of the nation's housing stock was reduced by £2.48bn because of landfill.

The survey looked at the sale of 592,000 houses over 10 years, and compared prices of similar properties near the 11,300 landfill sites in the country. Houses within a quarter of a mile of a site were worth on average £5,500 less and those between quarter and half a mile £1,600 less.

...purpose of the survey was to help the Treasury measure the loss of amenity ... by landfill so the landfill tax could be fixed accordingly.

...ironment minister, said: "It is not surprising people do ... but until now we had no real measure of the ...

Nieuws | Economie | Cultuur & Leven | WETENSCHAP

de Volkskrant

Hoe dichter bij windmolens, hoe meer de huizenprijs daalt

Huizen dalen in waarde als er windparken in de omgeving verschijnen, al is het minder dan veel huiseigenaren denken. Bij de hoogste windmolens loopt het verlies op tot 5 procent of meer. De kans op schadeclaims neemt hierdoor sterk toe.

Door: Jeroen Trommelen 19 april 2016, 06:08

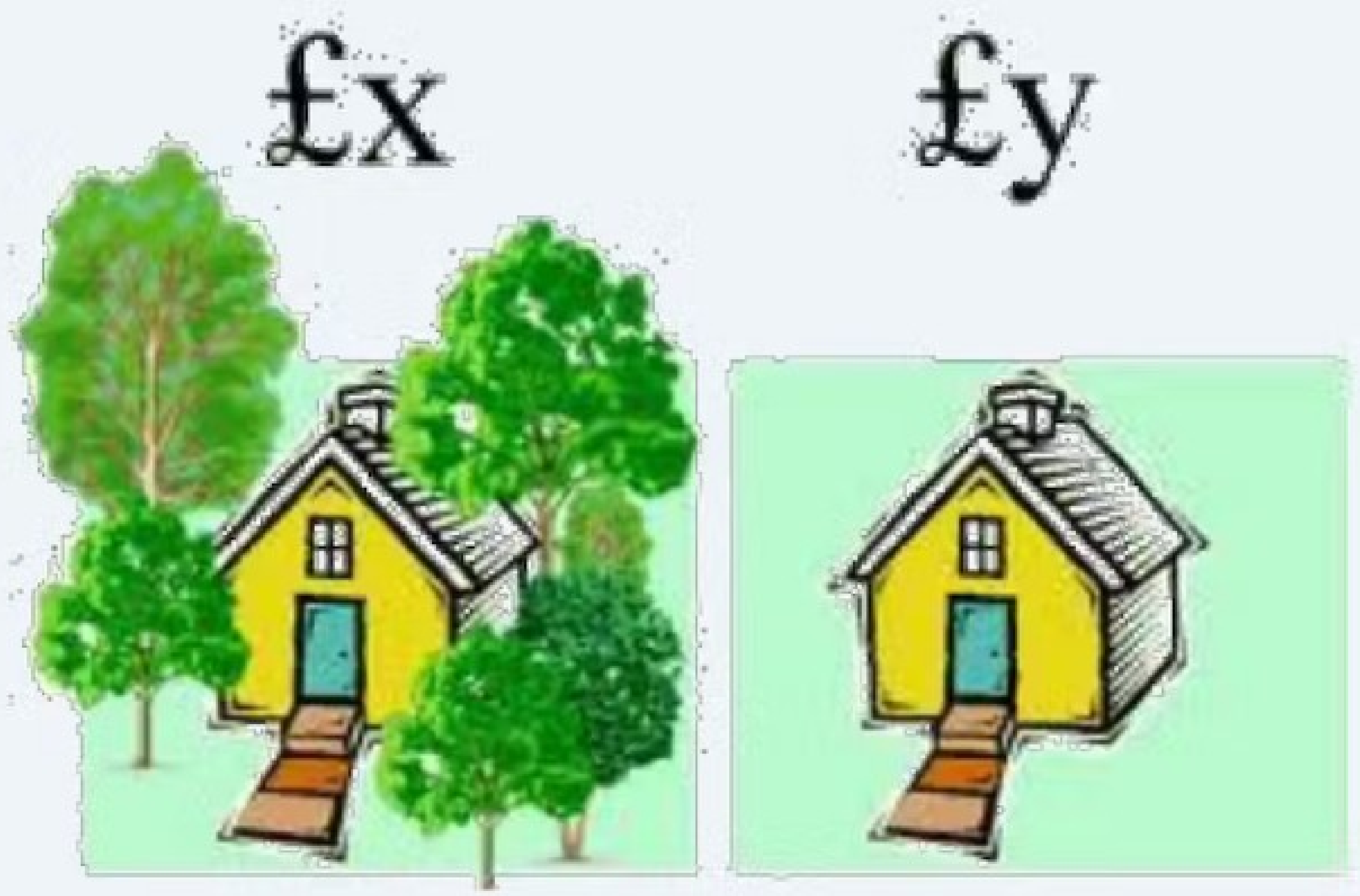
'Ik ben tegen, want mijn huis wordt minder waard.' In de directe omgeving van een te bouwen windpark is dat argument niet helemaal uit de lucht gegrepen, zeggen onderzoekers van het Tinbergen Instituut. De ...

Blijf op de hoogte

Elke avond om 20.30 het laatste nieuws en alvast zes artikelen uit de krant van morgen in je mailbox? Schrijf ...

1. Introduction

- We focus on the housing market
- Hedonic price theory is often used to measure the price of public goods



1. Introduction

- Often used in applied research to answers questions like:
  - Is it beneficial to invest in a new park?
  - What are the social costs of a polluting power plant?
  - Are there any external effects of investments in poor neighbourhoods?
  - What is the effect of earthquakes?
  - ...

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1. Introduction

Goals of this class are:

1. Understand what a hedonic price function
2. Have basic knowledge about how a hedonic price function is linked to economic theory

- Next lecture: more on estimation and price indices

- Literature: syllabus

2. The marginal willingness to pay

A hedonic price function is:

- A description of the equilibrium prices of varieties of a heterogeneous good influenced by supply and demand
- Is not expected to be stable over time
- Economic theory does not tell much about the shape of the hedonic price function

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2. The marginal willingness to pay

- Consider a heterogenous good
- Heterogeneity is described by a number of attributes k.
- Price is a function of these attributes, so $p = p(k)$.
- If there are enough observations, we can estimate $p(k)$.

2. The marginal willingness to pay

- Hedonic price function developed by Andrew Court (1939) in application to cars

- Extended by Zvi Griliches (1961)
  - Also applied to cars
  - Since then a standard econometric tool

- Rosen (1974) provided a link between the hedonic price theory and standard economic theory

2. The marginal willingness to pay

- **How is the hedonic price function related to economic theory?**

- **Let's assume a utility maximising household**
  $u = u(q, k)$
  q **denotes a composite good**
  k **denotes an attribute *(e.g. house size)***
  subject to a budget constraint $y = q + p(k)$.

- **Then, it holds that:**
  $$\frac{\partial u / \partial k}{\partial u / \partial q} = \frac{\partial p}{\partial k}$$

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2. The marginal willingness to pay

$$\frac{\partial u/\partial k}{\partial u/\partial q} = \frac{\partial p}{\partial k}$$

- It indicates the amount of money a consumer is willing to pay to get an additional unit of the attribute
  - An additional square meter of house size
  - Engine power for cars
  - *while holding utility constant*

- Problem: households are not homogeneous in their utility functions!

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3. The value function

- **To analyse the equilibrium we may use the concept of the 'value function'**
  - **We may write $u_1 = u_1^* = u(y_1 - P_1, k)$.**
  - **We then invert the utility function with respect to $y_1 - P_1$ to obtain $P_1 = y_1 - u^{-1}(u_1^*, k)$**

  - $\frac{\partial P_1}{\partial k} = \frac{\partial u/\partial k}{\partial u/\partial q}$ ➔ **MRS is equal to implicit price for k**
  - $\frac{\partial P_1}{\partial y_1} = 1$ ➔ **Δy translates completely into ΔWTP**
  - $\frac{\partial P_1}{\partial u_1^*} = -\frac{1}{\partial u/\partial k}$ ➔ **WTP for good decreases in $\bar{u}$**

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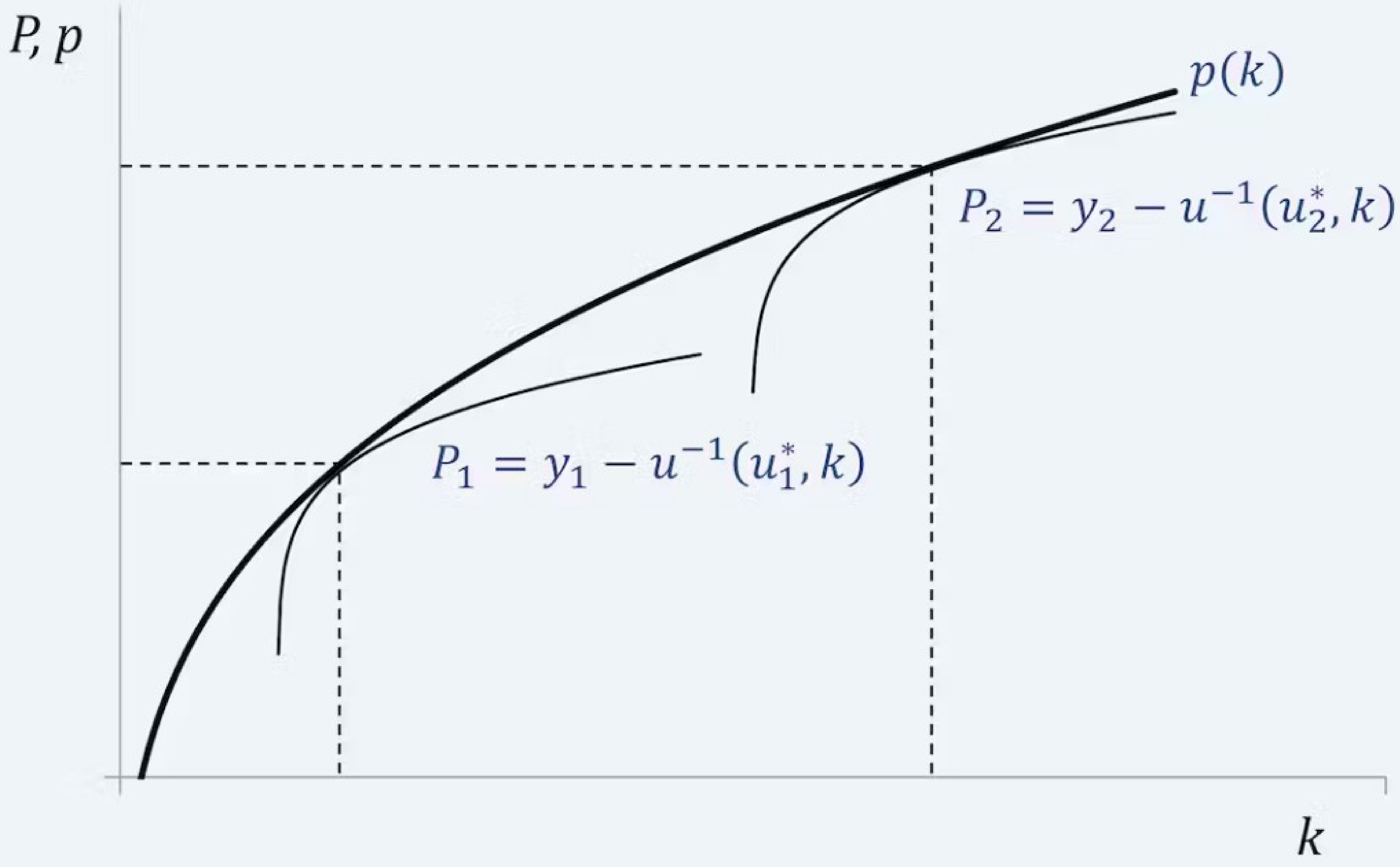
3. The value function

- **With heterogenous households, we have:**



- **Note that the *value functions* give the WTP, (P_1, P_2) for different consumers**
- **Hedonic pricing function $p(k)$ gives market price**

4. Demand functions

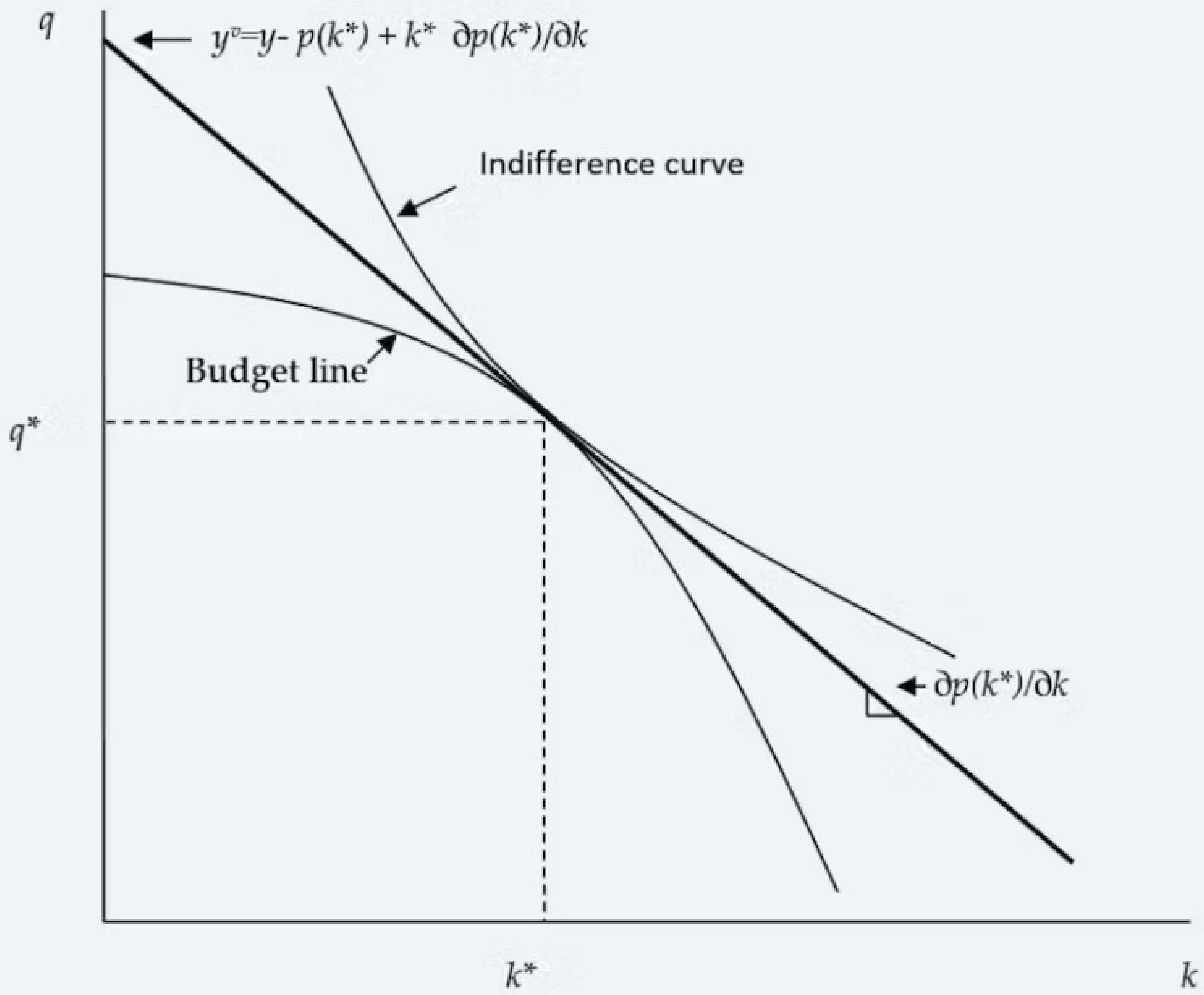
- Recall that $\frac{\partial u/\partial k}{\partial u/\partial q} = \frac{\partial p}{\partial k}$

- So what can we learn from the data if we estimate a hedonic price function?
  - We aim to obtain $\partial p/\partial k = \alpha$

- Can we determine the *demand* for an attribute k for an individual if we obtain α?
  - *e.g.* demand for open space
  - Demand function: $k = f(\alpha)$
  - Inverse demand function: $\alpha = f(k)$

4. Demand functions

- **The budget constraint:** $y = q + p(k)$
- **A problem: there is no constant unit price of quality** k
  - **The price (or willingness to pay) depends on the amount consumed**

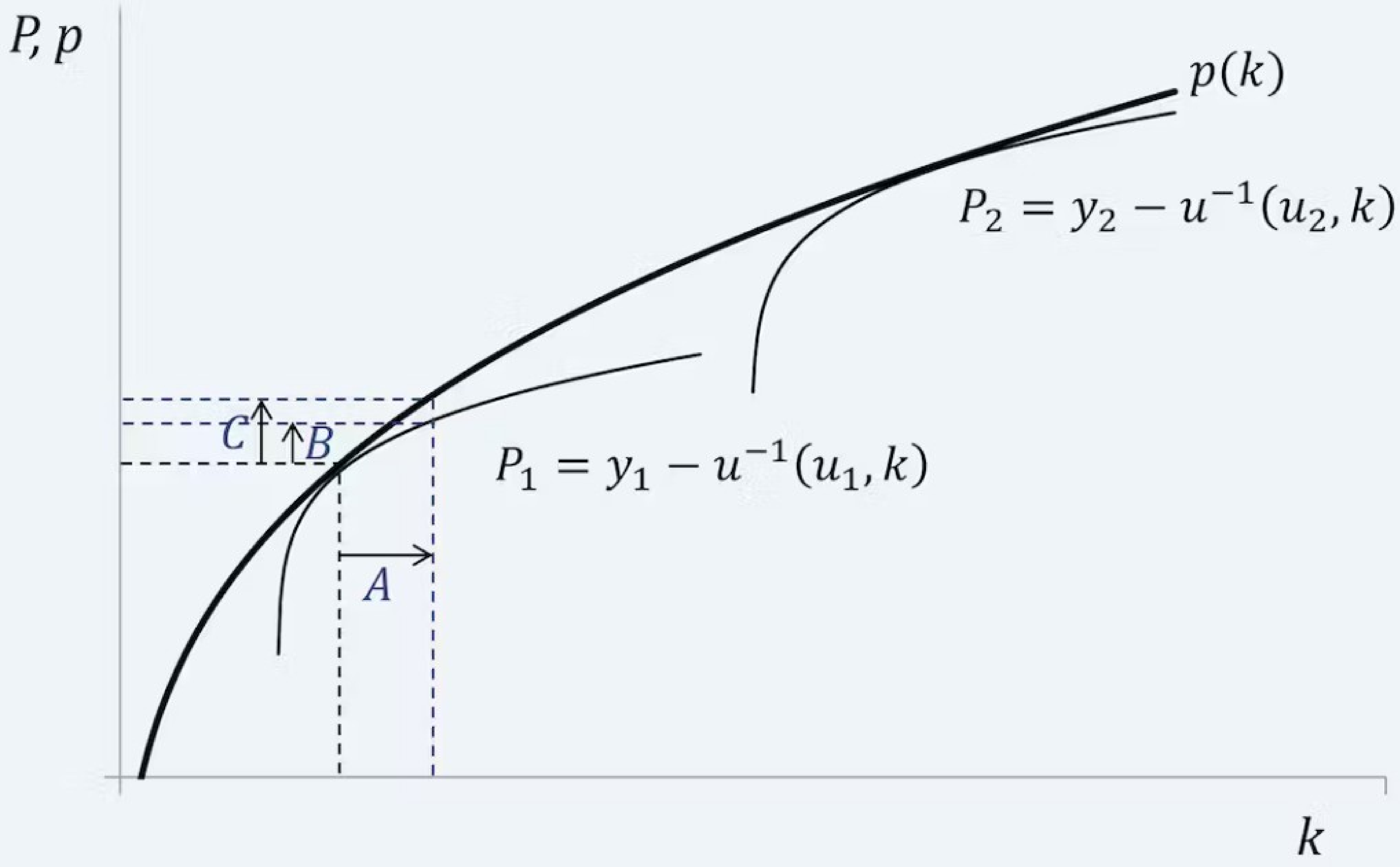


4. Demand functions

- **Homogeneity:**
  - **In practice we usually calculate the average of the WTP**
  - **We often do not attempt to estimate structural utility/demand parameters but focus on *marginal changes***
  - **Hence, we only identify the point on the value function that touches the equilibrium price function**

4. Demand functions

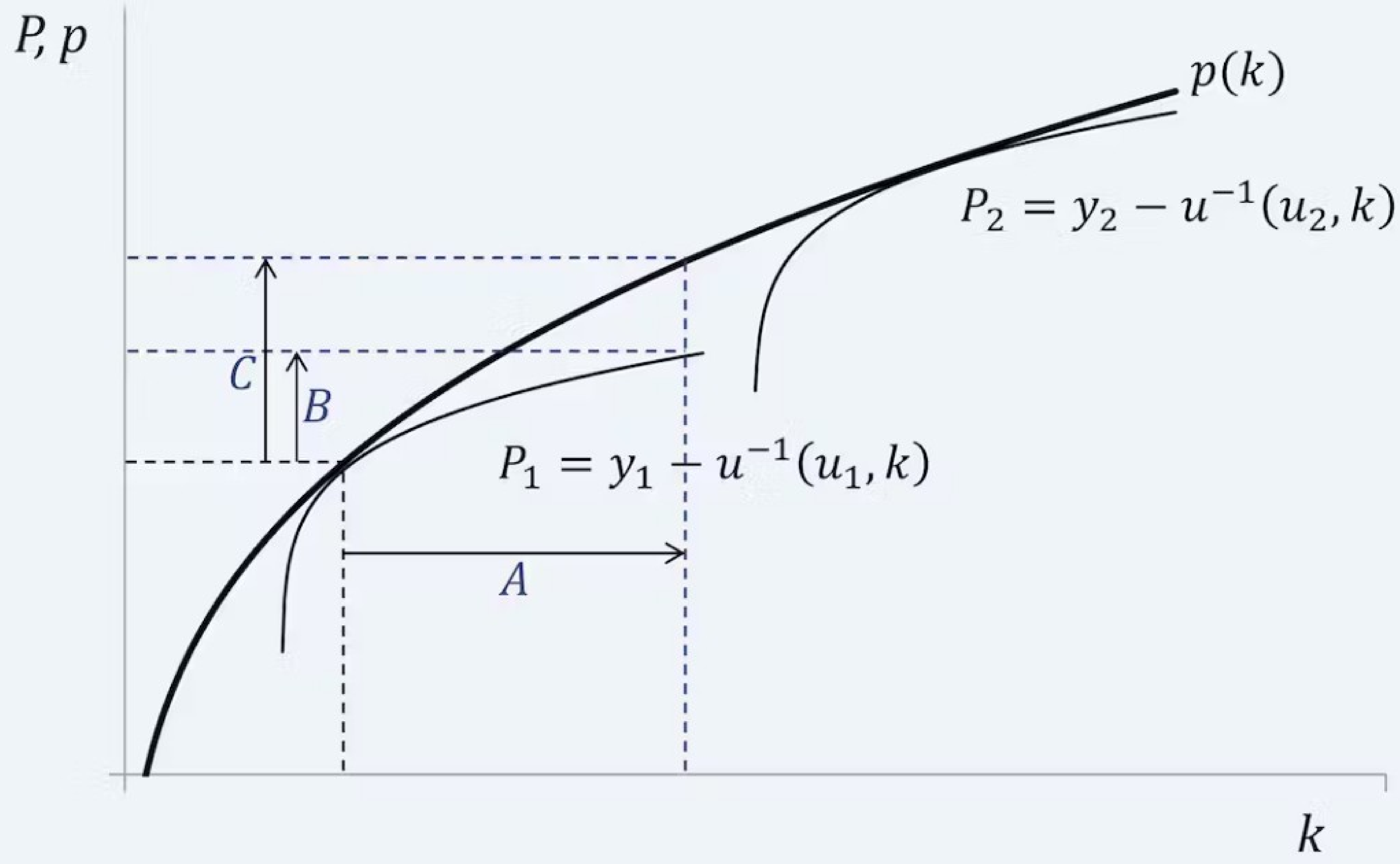
- **Structural (large) vs. marginal (small) changes in k**



- **Let's consider a *small* change in k**
  - **What is the actual willingness to pay?**

4. Demand functions

- **Structural (large) vs. marginal (small) changes in k**



- **Let's consider a *large* change in k**
  - **What is the willingness to pay?**

4. Demand functions

- **To identify demand functions, Rosen (1974) suggested a three-step procedure**

  1. **Estimate a hedonic price function**
  2. **Calculate the implicit prices**
  3. **Estimate the inverse demand functions by a regression of marginal prices $\partial p / \partial k$ on the amount consumed of attribute k**

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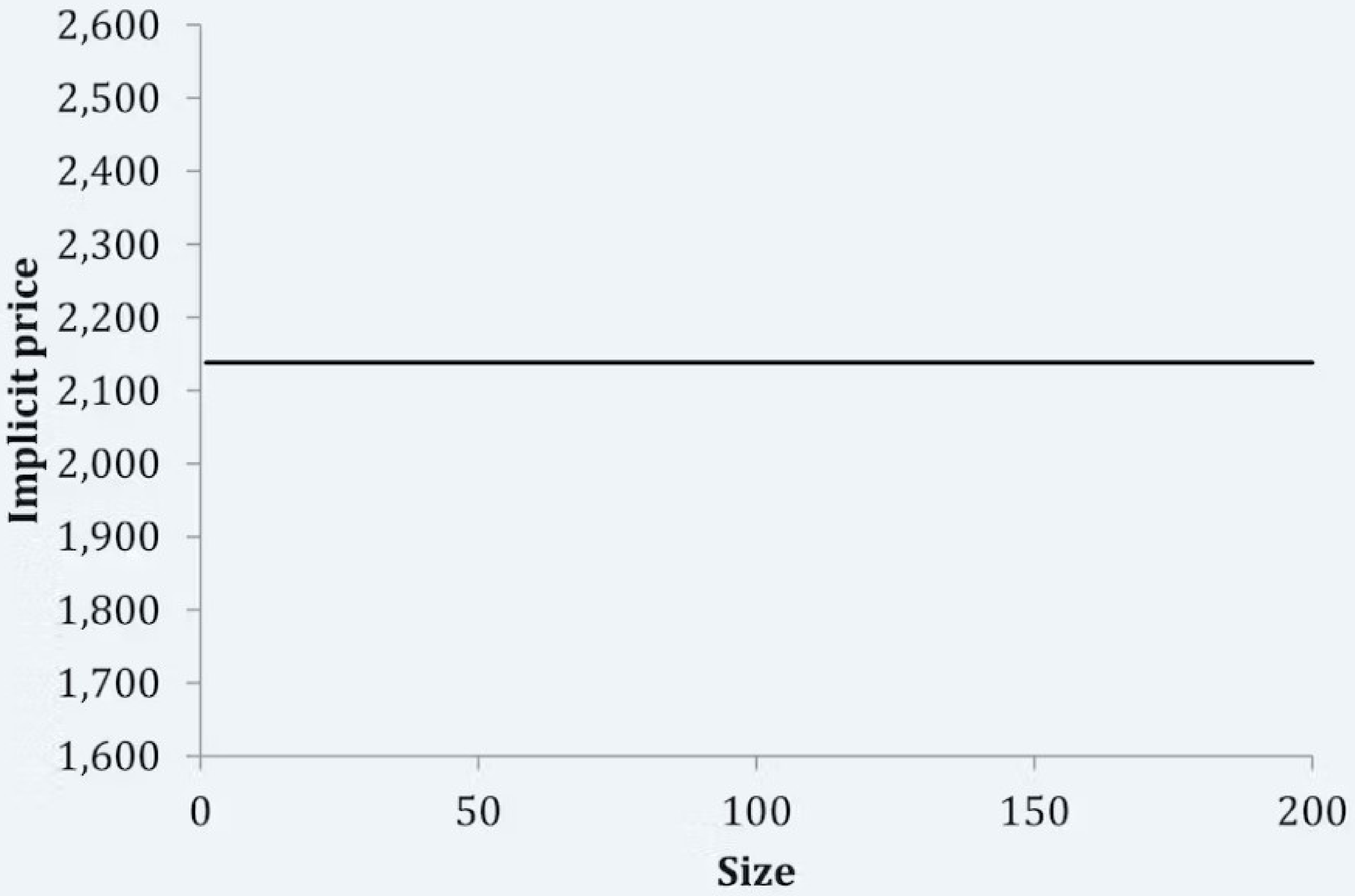
4. Demand functions

- **Example linear hedonic price function:**

1. **Estimate hedonic price function**

   $$p_i = \alpha_0 + \alpha_1 k_i + \xi_i$$

2. $\frac{\partial p_i}{\partial k_i} = \hat{\alpha}_1 = 2139$

3. 

4. Demand functions

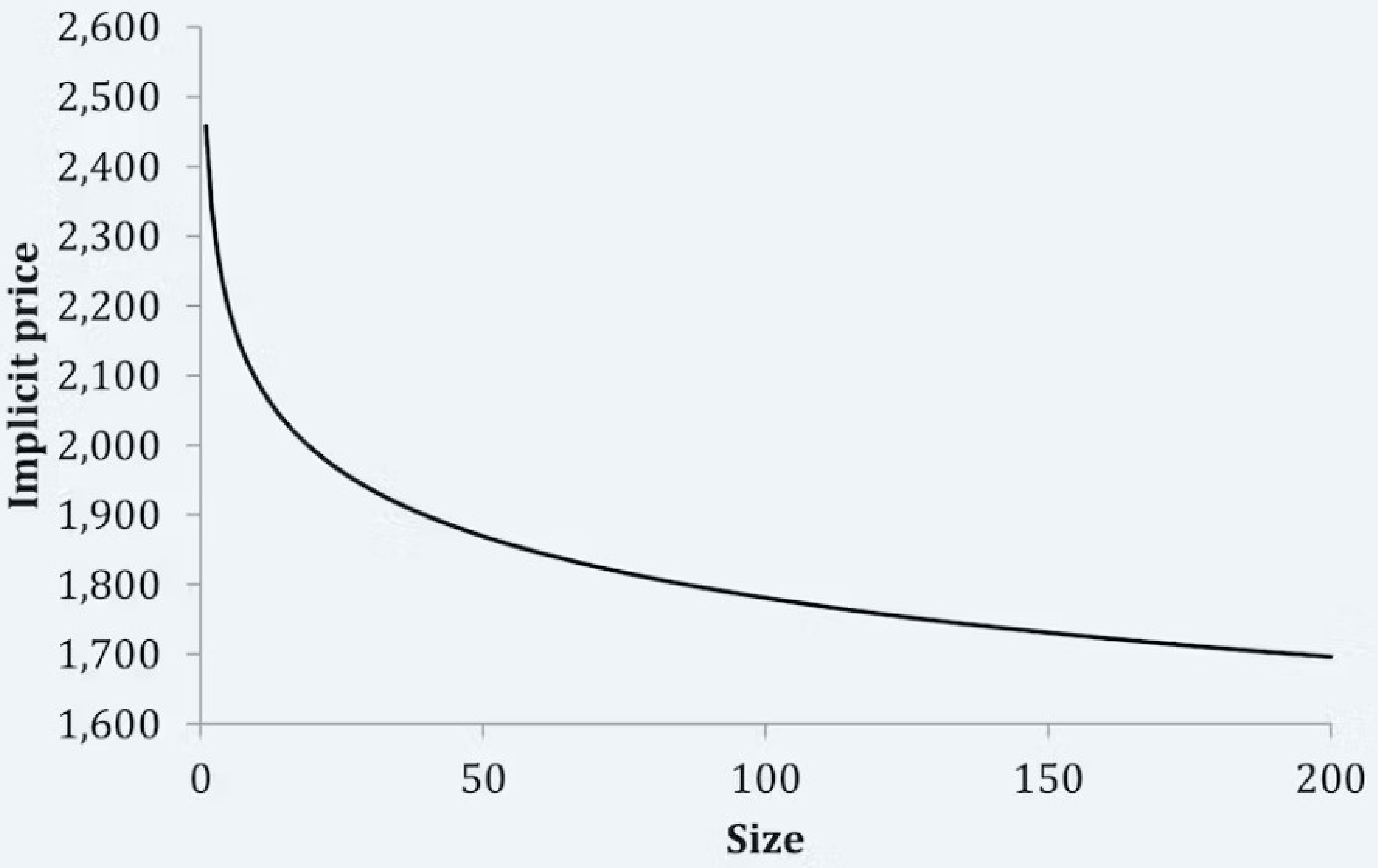
- **Example log-linear hedonic price function:**

1. **Estimate hedonic price function**

   $$\log p_i = \alpha_0 + \alpha_1 \log k_i + \xi_i$$

2. $\hat{\alpha}_1 = 0.9276; \frac{\partial p_i}{\partial k_i} = \frac{\hat{\alpha}_1 p_i}{k_i}$

3.



4. Demand functions

- The procedure to obtain demand functions is misleading
  - Demand functions entirely depend on assumed functional form of hedonic price function

4. Demand functions

- There are some solutions to the identification of demand functions:

  - Use *multimarket* data
    - Utility functions are identical across markets but WTP is different

  - Use *multiple observations* for each individual
    - Bishop and Timmins (2018)

  - Nonparametric methods
    - Ekeland *et al.* (2004)
    - Bajari and Kahn (2005)

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Hedonic pricing (2)

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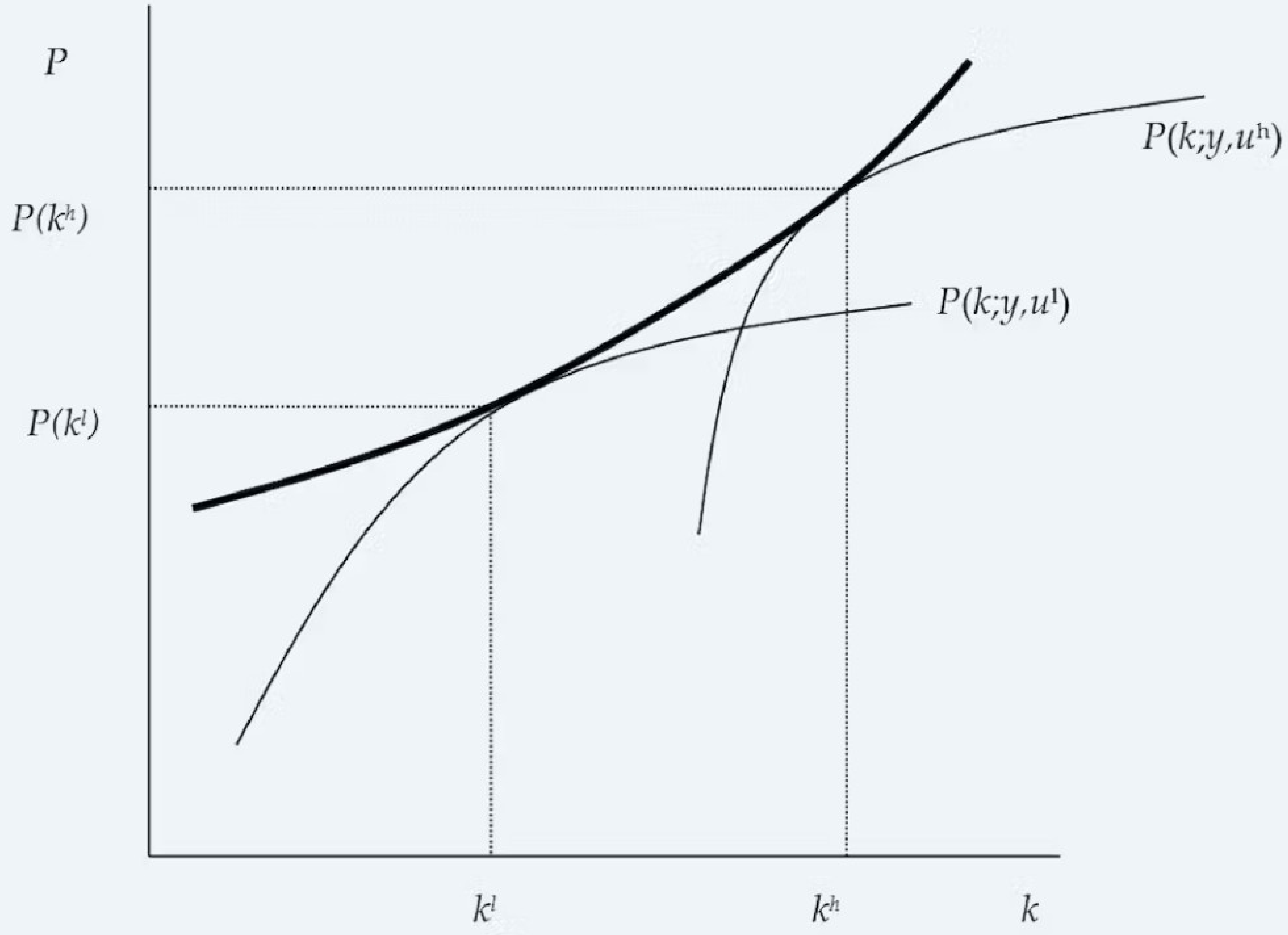
1. Introduction

- **Hedonic price functions are used to answer a lot of policy related questions**
- $p_i = \alpha_0 + f(k_i) + \xi_i$
- **However:**
  1. **Misspecification**
  2. **Endogeneity**

2. Misspecification

- **Recall: the hedonic price function is formed of different people attaching different values to a good**



2. Misspecification

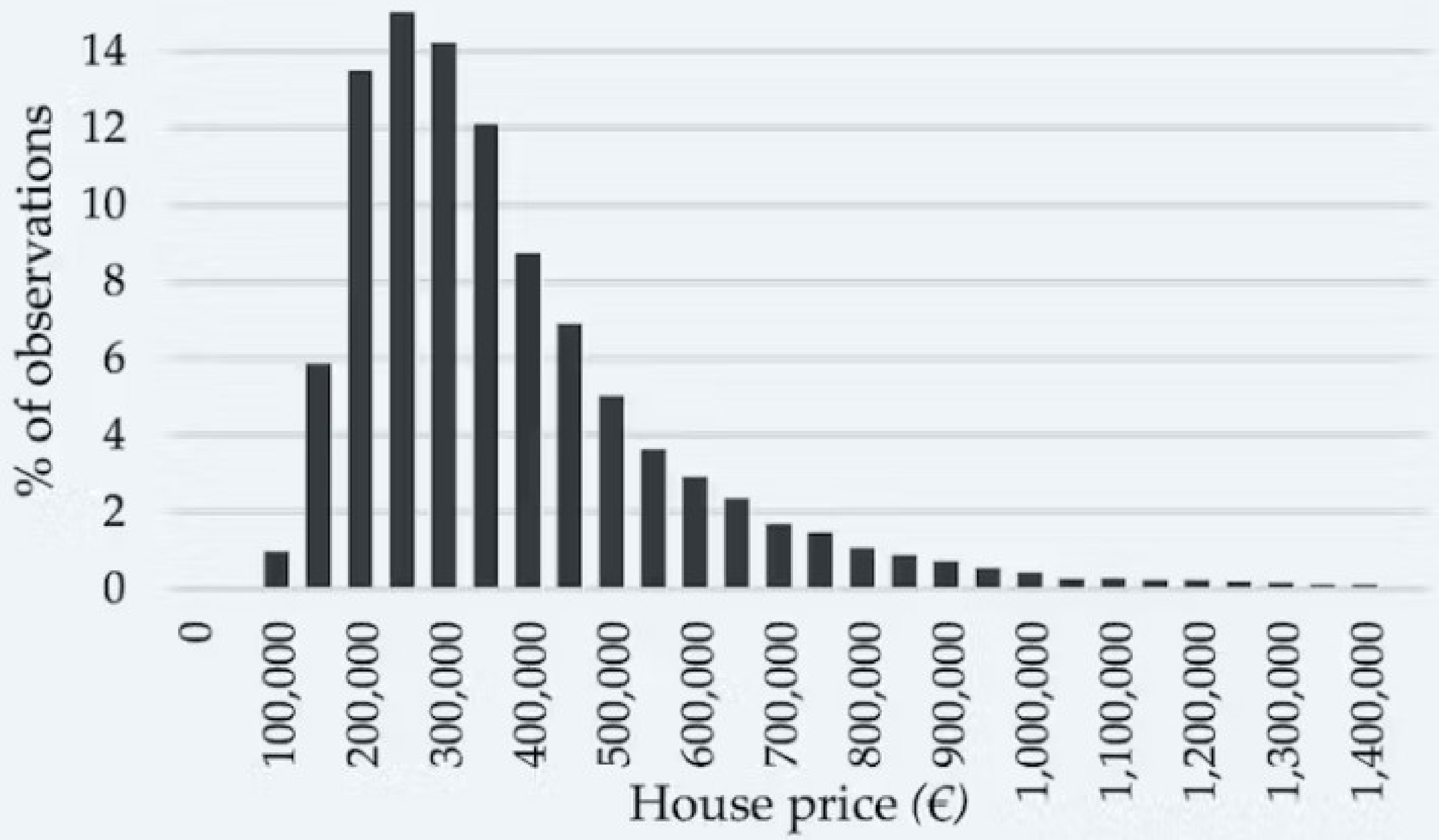
- **We have the following hedonic price function:**
  $p_i = \alpha_0 + f(k_i) + \xi_i$

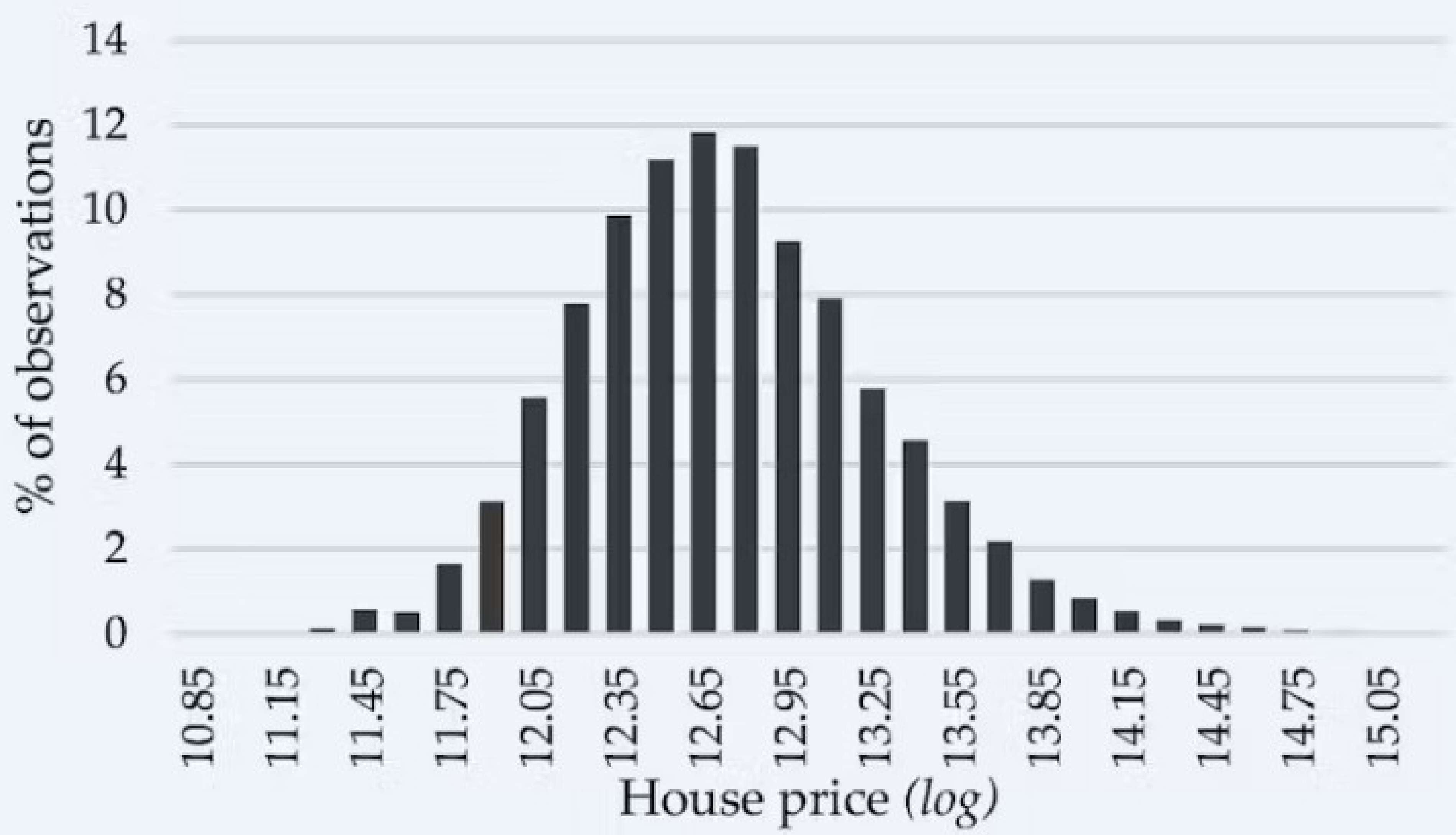
- **Functional form is unknown**
  - **May be highly nonlinear due to heterogeneity**

2. Misspecification

- **Logarithmic functions are often assumed:**
  $\log p_i = \alpha_0 + \alpha_1 \log k_i + \xi_i$
  $\log p_i = \alpha_0 + \alpha_1 k_i + \xi_i$

- **Common feature of house price data: skewness**
  ... issue of skewness is then addressed





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2. Misspecification

… But log-linear hedonic price functions can still be considered as restrictive

- Recall that we had the following hedonic price function:
  $p_i = \alpha_0 + f(k_i) + \xi_i$

- How should we estimate the above price function?
  - Nonparametric/semiparametric econometric techniques!
  - Put less structure on the data

- Nonparametric ➔ no structure
- Semiparametric ➔ a bit of structure

2. Misspecification

- **Let's focus on two semiparametric estimation methods**
  - **Series approximation**
  - **Locally weighted regression (LWR)**

- **Series approximation**
  - **Estimate Taylor-series expansion**
  - **E.g., add k_i^2 and k_i^3.**
  - **So,** $\log p_i = \alpha_0 + \alpha_1 k_i + \alpha_2 k_i^2 + \alpha_3 k_i^3 + \xi_i$

2. Misspecification

- **Series approximation**
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- **Pros and cons**
  - **Linear in parameters**
  - **Problem if you have many explanatory variables**
  - **Sometimes not flexible enough**
  - **Performs poorly in 'boundary' regions**

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2. Misspecification

- **Locally weighted regression**
  - **Estimate for each observation a *weighted* regression**
  - **Let weights be higher for observations that are 'similar'**
  - **So, $\log p_i = \alpha_0 + \alpha_i k_i + \xi_i$ where i is the observation**
  - **Run weighted regression for each observation**
    - › **Weights depend on value of k_i**

2. Misspecification

- **Locally weighted regression**
  - **Weights depend on value of k:**

$$w_i = \frac{1}{h\sqrt{2\pi\sigma_k}} e^{-\frac{1}{2}\left(\frac{k-k_i}{\sigma_k h}\right)^2}$$

  - **Looks difficult, but weights are based on a normal distribution**

- h **is the bandwidth**
  - $h = 0$**, only take observation** i **into account**
  - $h \rightarrow \infty$**, identical to linear regression**

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2. Misspecification

- **Locally weighted regression**
  - **Weights depend on k_i:**

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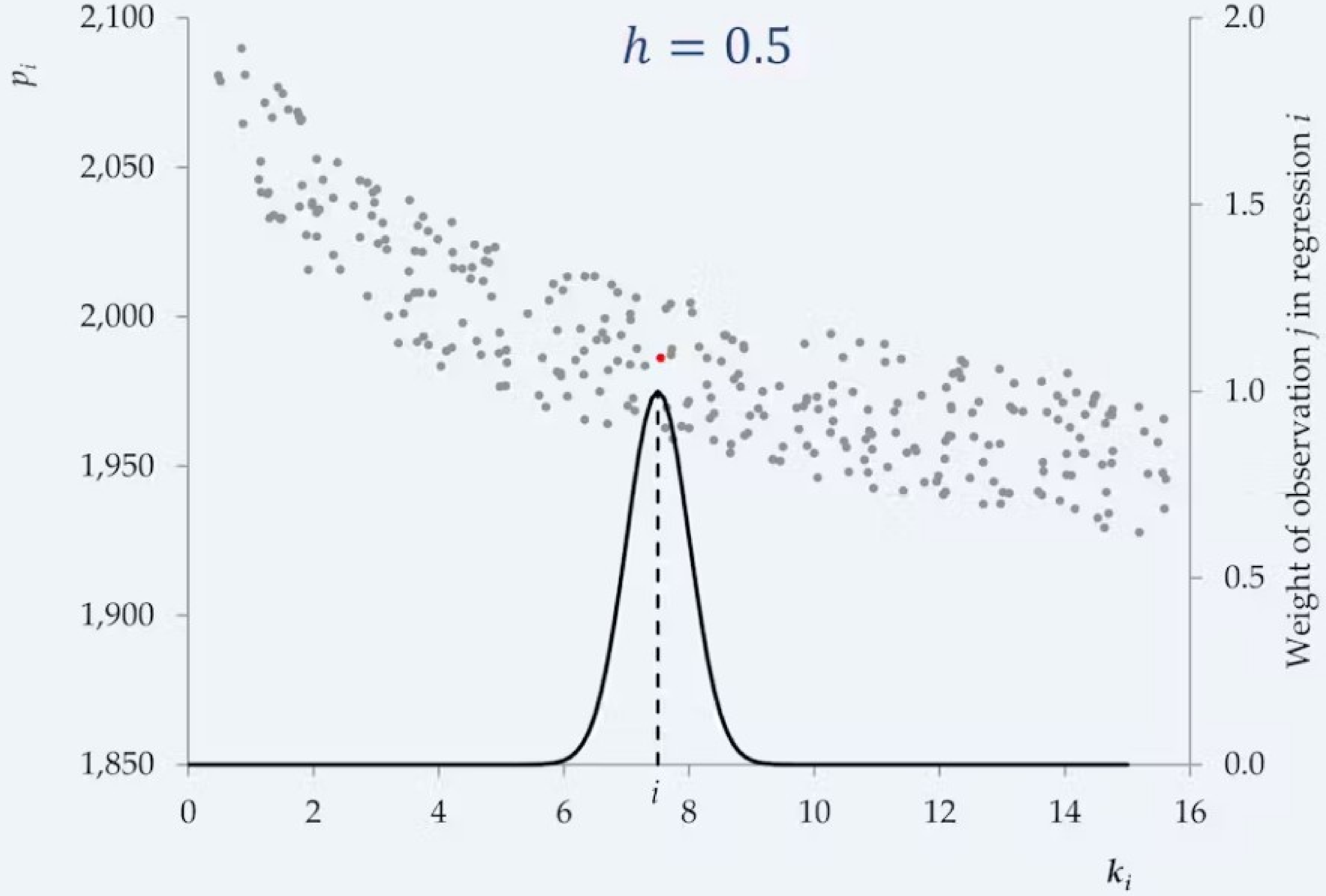

2. Misspecification

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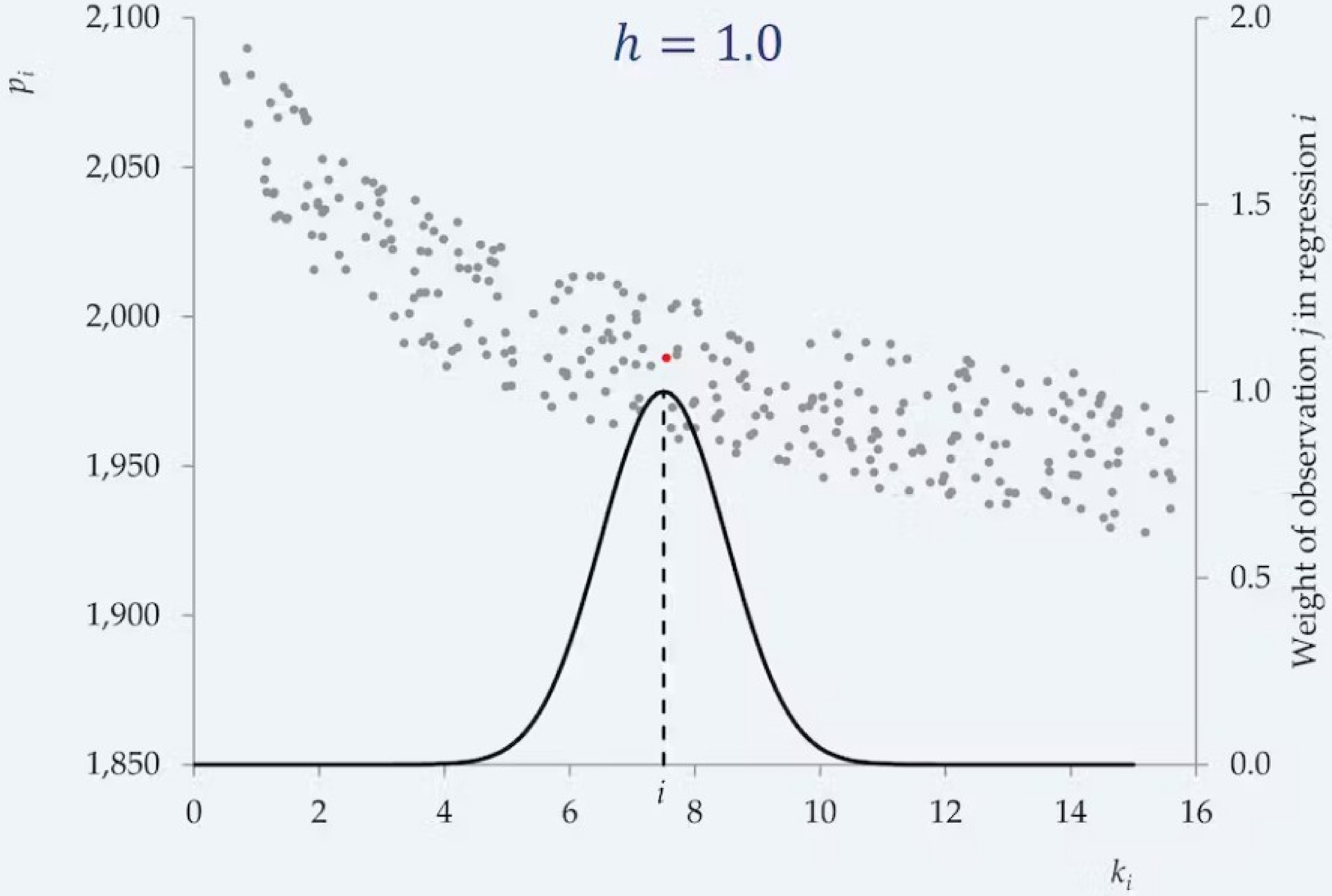

2. Misspecification

- **Locally weighted regression**
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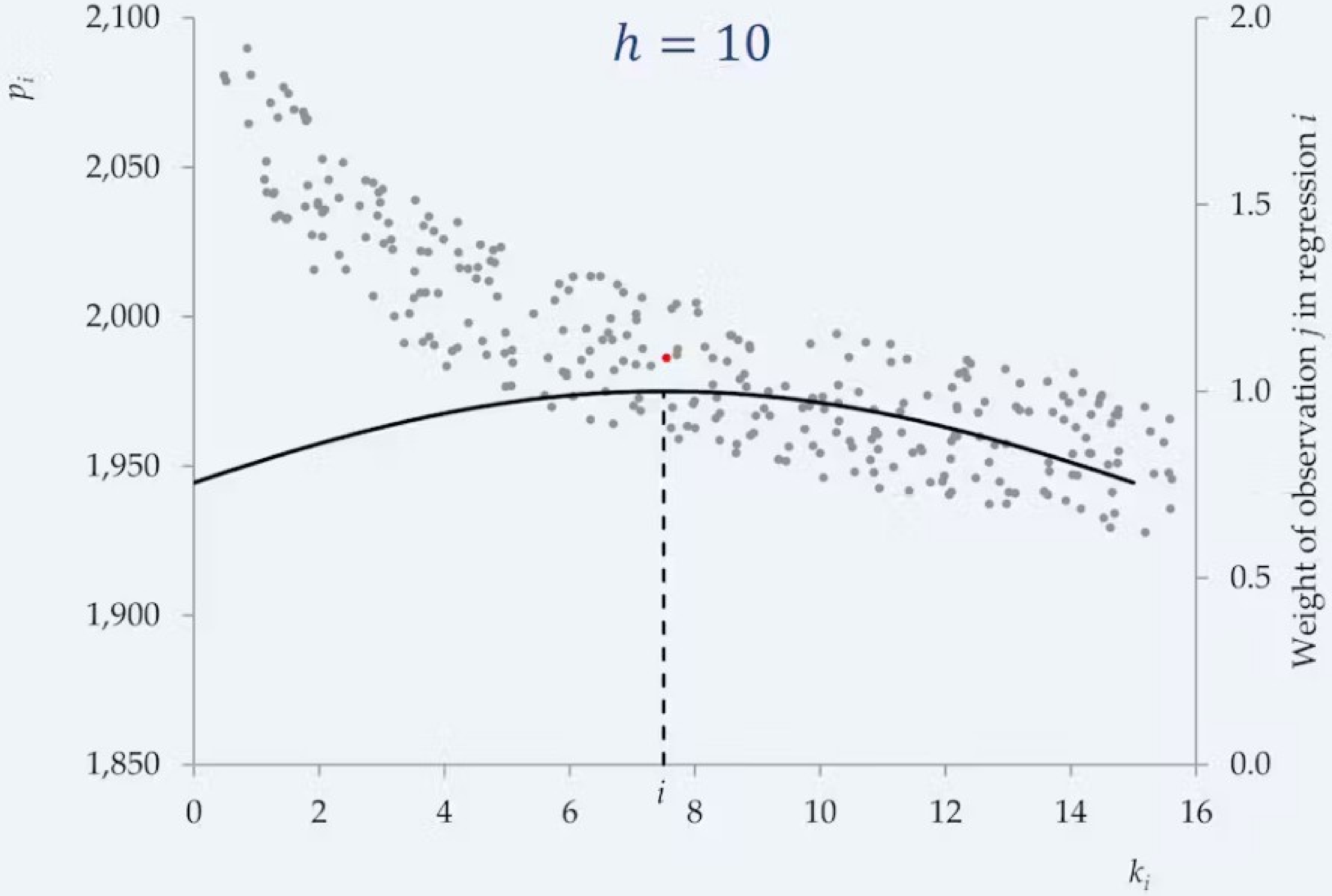

2. Misspecification

- **Locally weighted regression**
  - **Very flexible**
  - **Easy to estimate implicit prices** $(\partial p_i / \partial k_i = \alpha_i)$
  - **Bandwidth is important parameter; determines smoothness**
  - **Becomes popular in applied research**
    - **Bajari and Kahn (2005)**
    - **McMillen and Redfearn (2010)**
  - **Use for example** NPREGRESS **command in STATA**

- **But: computationally intensive!**
  - **It takes very long to estimate when** $N \gtrsim 50000$

2. Misspecification

- **How to estimate partially linear functions?**

  $p_i = f(k_i) + \beta x_i + \xi_i$

  - **Use series estimation**
  - **Use Robinson's procedure**
    - PLREG **in STATA**

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3. Endogeneity

- **Omitted variable bias (OVB) is a big issue when estimating hedonic price functions**
  - **So:** $\log p_i = \alpha_0 + \alpha_1 \log k_i + \xi_i$
  - **If** $\mathrm{E}[\xi_i | k_i] \neq 0$, α_1 **will be inconsistent**

5. Summary

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Hedonic pricing:

1. **Understand what a hedonic price function**
   - *A description of the equilibrium prices of varieties of a heterogeneous good*

2. **Have basic knowledge about how a hedonic price function is linked to economic theory**
   - *Heterogeneous households have different WTPs for goods*

3. **Understand how to address misspecification and endogeneity when estimating hedonic price functions**
   - *Estimate log-linear hedonic price functions*
   - *Series approximation / LWR*
   - *Add controls and fixed effects*
   - *Consider IV/quasi experiments*

Hedonic pricing (2)

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