Econ 330: Urban Economics

Lecture 6

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23 January, 2020

Lecture 6: Land-Use Patterns

Schedule

Today

1. **Hand in HW and Admin**

2. **Von Thunen Rings**

3. **Monocentric City**

Upcoming

- **Reading** (Chapter IV *ToTC*)

✅✅ HAND IN HW ✅✅

Admin

- I will post the *ToTC* book report instructions on Canvas after class. **Due end of week 9**

    - I will give you another reminder around week 6

    - Feel free to turn it in earlier

- 1000 words (roughly 2 to 2.5 pages single spaced)

- **This must be your own work**. You can discuss ideas with your friends but the writing **must** be your own

    - ⚠️ Plagiarism will be dealt with harshly ⚠️

Admin

⚠ The next 3 weeks or so of this class are probably the most algebra intensive of the term ⚠

- For many of you, this means the difficulty of the course will ramp up a bit

- If you have anxiety about math, come see me. I am happy to help 😃

Checklist

2) **Turn in HW & Admin** ✅

2) **Von - Thunen Model**

3) **Manufacturing Bid Rent**

Rents

- **Last time**: we looked at rents across cities and the consumer bid rent curve.

    - **Consumer bid rent**: Informs how prices for urban rental/housing units change with distance to center

- **Today**:

    - **Von Thunen Model**: (urban rural interface)

    - **Manufacturing bid rent** (different assumptions)

- **Next Class**

    - A small note on Office rents and neighborhood choice part 1

Von Thunen Rings

1826: Johann Heinrich von Thunen writes *The Isolated State*

- Foundational model of Human Geography

- Model describes interaction between cities and landscapes

- Uses basic economic principles to predict changes in land-use

What we will do: use the model to inform **agricultural rents** and predict **physical size** of cities

Von Thunen Model

Why do we care about a model developed in 1826?

- Current theories usually aim to explain the world as it is, or will be in the future

- The question of city location can be better understood via economics, history, and geography

- Factors that influence the urban rural interface still largely relevant today

Von Thunen Model

Assumptions

1) City is located in the center of a wilderness area

2) Farm land is equally productive throughout the city

3) Farmers behave rationally to maximize profit

4) Farmers transport their goods to a central location in the city

Von Thunen: Rings
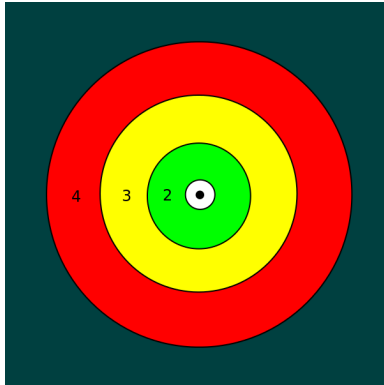
- **Black Dot**: the city

- **White circle**: Dairy Products

- **Forest for fuel**

- **Grain and crops**

- **Ranching**

What do you notice?

- The rings go out from the center in order of transit cost. **Dairy**: spoils quickly and heavy. **Trees**: heavy. **Grain**, easier to transport, but still heavy. **Ranching**: land intensive

Von Thunen Model: Math

Von - Thunen (rural) rents are derived from the **zero profit condition**. We will work with a simple version, for now, where there is only one "ring" (we can call this agriculture)

$$\pi = TR - TC$$

- $TR = P * Q$

- $TC(x) = F(x) + C + R(x)$

- $R(X)$: Land rents

- Q, P: price and quantity

- C: intermediate goods cost

Von Thunen Model: Math

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- $TC(x) = F(x) + C + R(x)$

- $R(x)$: Land rents

- Q, P: price and quantity

- C: product expense per unit of commodity

- $F(x)$ transit cost x mi from center

Von Thunen Equation

Profit equation is given by:

$$\pi = P * Q - F(x) - C - R(x)$$

Zero profits imply:

$$P * Q - F(x) - C - R(x) = 0$$

Solving for $R(x)$:

$$R(x) = (P * Q - F(x) - C)$$

Von Thunen Equation

So the **agriculturual bid rent** or **von thunen bid rent** curve is summarised by:

$$R(x) = (P * Q - F(x) - C)$$

In words, what does this equation say? **Discuss**

- Higher Revenue (P*Q) $\implies$ higher rents (why?)

- Higher Freight cost (F(x)) $\implies$ lower rents

- Higher Intermediate goods cost (C) $\implies$ lower rents

Von Thunen Model: Example

Using

$$R(x) = (P * Q - C - F(x))$$

Find the *radius of arable land* when freight costs are given by: $F(x) = B * x$

- That is, find the distance from the city where $R(x) = 0$

- Set $R(x) = 0$ and solve for x

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$$C - P * Q = -B * x$$

Von Thunen Model: Example

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$$0 = (P * Q - C - B * x)$$
$$C - P * Q = -B * x$$
$$\frac{P * Q - C}{B} = x$$

Interpretation

What does the equation $\frac{P*Q-C}{B} = x$ tell us?

1. If the freight rate B, increases, will the agricultural area surrounding the city get smaller or larger?

- **Smaller**, $\frac{1}{10} < \frac{1}{5}$

- Interpret this

As it becomes more expensive to ship goods, the oppurtunity cost of living further from the city center (where the exchange occurs) increases. Thus, the urban-rural area shrinks in radius

Von Thunen: Multiple Sectors

Now consider a version of the model in which we have 2 sectors and **no transit costs**. Profit in each sector is given by

$$\pi_1 = P_1 * Q_1 - R(x_1)$$
$$\pi_2 = P_2 * Q_2 - R(x_2)$$

Assume the following:

- $P_1 * Q_1 > P_2 * Q_2$ (rev in sector one is greater than sector 2)

- $R(x) = 20 - x$

task: Show that industry 2 is further away from the center and they pay lower rents. Hint: use the *radius of arable land* idea from above

Von Thunen Example

Von Thunen Model: So What?

The model is a bit dated, but still useful

- Transportation costs have, and have always had heavy influence on land prices

- These constraints were larger in the past; still might be useful in explaining urban form of certain cities

- Radius of arable land can give predictions on urban-rural size

- City and agricultural area are intimately linked (Read Cronon's *Natures Metropolis*!)

Thoughts on the model? What assumptions do you like? What do you not like? **Discuss**

Checklist

1) **Turn in HW & Admin** ✅

2) **Von - Thunen Model** ✅

- Von Thunen Rents

- The radius of arable land

3) **Manufacturing Bid Rent**

Manufacturing Bid Rent

WTP for land from manufacturing firms is a function of the land's accessibility (similar to consumers)

- **Fact**: Urban manufacturing employment is largely decentralized and disperesed

    - Most firms locate close to the highway. **Why**? This has not always been the case

- Firms are balancing **freight** and **labor costs**

    - Further from labor $\implies$ higher wage (to compensate for increased commuting cost)

    - Further from shipping center $\implies$ higher freight cost

Manufacturing Bid Rent

Let's start with a simple model™ . **Assumptions**

1) Input & Output **prices** & **quantities** are fixed

- Firm only decides location

2) Firms import intermediate goods and export output to other cities via a **central terminal** (train)

3) Wage paid is to compensate workers for commuting. Workforce is suburban so wage is highest at center

4) Firms use horse carts to transport inputs and output to the **central terminal**

- We will relax this one soon

Firm's Bid Rent

What do we use to get the firm's bid - rent equation?

Axiom 5: *Competition generates zero economic profit*

Recall the profit equation:

$$\pi = TR - TC$$

In this model:

- $TR = P * Q$ (fixed, exogenous)

- TC is a function of freight cost, labor cost, and intermediate goods cost:

$$TC(x) = \text{Freight Cost}(x) + \text{Labor Cost}(x) + \text{Land Cost}(x) + \\ \text{Intermediate Input Cost}$$

Firm Bid Rent

From here on out, let's call $\textbf{Intermediate Input Cost} = \bar{I}$

- Invoking zero economic profit, from the last slide we can write:

$$TR - (\text{Freight Cost}(x) + \text{Labor Cost}(x) + \text{Land Cost}(x) + \bar{I}) = 0$$

- **In words**: The most a firm would be willing to pay for land then is revenue net of non land cost. Rearranging:

$$\text{Land Cost}(x) = TR - \text{Freight Cost}(x) - \text{Labor Cost}(x) - \bar{I}$$

Note: Land Cost = $P(x) * L_m$, where:

- $P(x)$ is the *price of land at x miles away from the center*

- L_m is the *amount of land the manufacturer uses in production* (fixed input at L_m)

We can replace land cost with $P(x) * L_m$ to get the equation for the **manufacturing bid rent** curve

$$P(x) * L_m = TR - \text{Freight Cost}(x) - \text{Labor Cost}(x) - \bar{I}$$

Firm Bid Rent: Equation

We can replace land cost with $P(x) * L_m$ to get the equation for the
manufacturing bid rent curve

$$P(x) * L_m = TR - \text{Freight Cost}(x) - \text{Labor Cost}(x) - \bar{I}$$

$$P(x) = \frac{TR - \text{Freight Cost}(x) - \text{Labor Cost}(x) - \bar{I}}{L_m}$$

In words, this equation says:

- Higher revenues $\implies$ higher land prices for every distance x

- An increase in freight costs, labor costs, or intermediate input costs will
  decrease the price for every distance x

Linearity

Note: If $\text{Freight Cost}(x)$ and $\text{Labor Cost}(x)$ are linear, then the firm bid rent curve is also linear.

Linearity

Linearity

Linearity

Manufacturing Graph

Back to Reality

Why would it be the case that $b_1 > b_2$ (freight rate relative to cost of moving people)

Transportation Innovations:

- Omnibus (1827)

- Cable Cars (1873)

- Electric Trolley (1886)

- Subways (1895)

In our model, what do these innovations do?

More History

- The *intracity* truck (1910): twice as fast and half as costly as the horse-drawn wagon[†]

- Truck decreased the cost of moving **output** `relative` to the cost of moving **workers**

- Manufacturing Firms moved closer to low-wage suburbs

The *intercity* truck (1930): alternative to ships and rail[††]

- **Highways**: orientation shifted from ports and railroad terminals to roads

- **Modern cities**: manufacturers oriented toward highways and beltways

† Intra = Within †† Inter = Across

Decentralization of Manufacturing

Wrapping Up

So we had two models, the Von Thunen Model (rural bid rent) and the manufacturing bid rent

- Both derived bid rent curves from **zero economic profit**

- Bid rent curves are different because **costs** faced by **agriculture** and **manufacturing firms** are different

- But the story and derivation behind them is pretty similar

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3) **Manufacturing Bid Rent** ✅

- Deriving the manufacturing bid rent curve

- Decentralization of manufacturing