Submitted to *Econometrica*

PECUNIARY EXTERNALITIES AND HEDONIC ASSETS

DOUGLAS PATTON
ORISE Fellow participating at US EPA, Office of Research and Development

To address a lack of attention to the welfare effects of house price returns generated by public policies that enhance environmental quality, I develop a dynamic model for a hedonic housing asset traded in a competitive market. The model distinguishes between the firm that owns each house and the consumers who rent. I derive present-value welfare change measures for non-marginal and marginal changes in amenities that are consistent with the static measures currently available. The dynamic welfare measures provide additional details about the distribution of benefits over time that reveal the inherent pecuniary externalities in hedonic asset markets that result in a transfer of economic benefits of amenity improvements from renter to owner. I also develop and consider a model extension specific to owner-occupied housing, and briefly discuss the policy implications of these results in the contexts of benefit cost analysis and environmental justice.

KEYWORDS: First keyword, second keyword.

1. INTRODUCTION

ECONOMIC ASSESSMENTS OF ecosystem service values frequently focus on quantifying direct economic benefits to households or consumers. The consumer oriented approach often follows from the way ecosystem services directly affect human well-being. However, in addition to direct impacts on human well-being, there are often price changes that accompany changes in ecosystem service flows. This is particularly evident with the hedonic price method, which uses changes in market prices to assess the benefits associated with improvements in environmental amenities that benefit households.

Douglas Patton: douglaspatton@gmail.com

We thank four anonymous referees. The first author gratefully acknowledges financial support from the National Science Foundation through Grant XXX-0000000.

The hedonic price method was grounded in the context of partial equilibrium of competitive markets by Rosen (1974). For much of the history of the method, identification of economic benefits required estimating a second stage demand function or making additional assumptions about the stability of the hedonic function across non-marginal variations in amenities (Freeman et al. 2014).

The relative price changes that accompany economic activity have been described as pecuniary external economies (Scitovsky 1954, Buchanan and Stubblebine 1962). Pecuniary externalities that arise due to market activity are not considered economically inefficient and do not contribute to deadweight loss. However, pecuniary externalities do affect well-being and when they arise as a consequence of public decision making, it is not appropriate to ignore the costs and benefits that spillover into related markets .

The hedonic price method of assessing the private benefits of ecosystem services to the occupants of housing is an apt example of a methodology that typically omits pecuniary effects from consideration. As discussed below, the hedonic price method relies on indirect changes in housing prices to quantify the economic values that occupants place on environmental amenities. The fact that the unit of housing as a productive asset has increased in value due to the improved amenities is generally ignored in the environmental economics literature.

In contrast to much of the environmental economics literature, other fields that consider changes in housing prices focus on price changes as they relate to the value of housing as an asset.

and those price changes can be used to . These price changes are pecuniary externalities and part of the way efficient markets function and benefits or costs that come about as a consequence of them are known as pecuniary externalities.

The consumer oriented approach is sensible because individual well-being is the fundamental concern of economics. Economic models allow for evidence of changes in consumption to be used to measure changes in well-being. and information about consumption opportunities obtained through active and passive use of ecosystem services. Many questions about ecosystem services focus on services that are public goods (non-excludable and non-rival) or club goods (non-excludable and rival). This makes sense in the context of public decision making and regulation because even well-functioning private markets are not expected to provide efficient levels of public and club goods.

However, understanding how people benefit from ecosystem services through the consumption of private goods (excludable and rival) also receives attention. Access to private real estate is a prime example of a private good that may be necessary for enjoying certain excludable ecosystem services. Hedonic valuation studies are generally recognized as a means for quantifying the economic benefits of these excludable ecosystem service values.

People can benefit from housing in two distinct ways: as the owner and as the renter. This distinction is embodied in the treatment of housing in national income accounting. National Income Accounts include new houses in the Private Fixed Investment category along with new factories, in the Rental Income of Persons category as well as in the Personal Consumption Expenditure category with food and recreation https://www.bea.gov/resources/methodologies/nipa-handbook. These categorized measures of aggregate trade flows from housing provide a framework for using the hedonic price method for quantifying economic benefits related to housing.

2. LITERATURE REVIEW

2.1. *Benefits of Amenities*

Freeman and more recently Freeman et al. are commonly cited as a source for theoretical underpinnings of the data and models used for estimating the benefits to housing consumers.

Freeman (1979) describes the process of aggregating the benefits to households of marginal improvements in amenities as a process of summing welfare measures based on analysis of household demand. Freeman (1999) asks, “how can we use the information on prices and preferences that can be extracted from the hedonic housing market to calculate measures of welfare change for changes in environmental amenities?”

Smith and Huang (1995) conducted an early meta-analysis of hedonic studies relating to air quality and considered only MWTP as a source of benefits. They also define MWTP as the “change in the asset value of the house”.

Zabel and Kiel (2000) discuss measuring the benefits to homeowners and their households" and focus exclusively on quantifying benefits related to consumer demand, as evidenced by their discussion of the indirect utility function when aggregating economic benefits for the purpose of benefit cost anaylsis. In their concluding remarks, Zabel and Kiel (2000) compare their results to Smith and Huang's (1995) results while describing them as benefits to the home owners.

Bui and Mayer (2003) quantify environmental amenity benefits by assessing their capitalization into housing prices. Bishop and Murphy (2011,2019) estimate dynamic models that include expectations about future prices

2.2. *External Economies*

In Economics, pecuniary and technological externalities have been defined to characterize interactions among market as well as political participants (Holcombe and Sobel 2001). Scitovsky (1954) discussed external economies in the context of industrial organization, distinguishing between technological and pecuniary externalities. Buchanan and Stubblebine (1962) generalized technological externalities to include consumers. Technological externalities have a directly impact on an external party other than through prices while the many effects of price changes are pecuniary externalities. Holcombe and Sobel (2001) suggest that because pecuniary externalities do not result in economic inefficiency the associated losses and gains have received much less attention. The direct mentions of pecuniary externalities in recent literature (e.g., Dávila and Korinek 2018) are largely confined to macroeconomic discussions related to investment and finance.

Externalities are also referred to as spillovers. Kelly (2011) discuss strategic spillovers where externalities are generated deliberately as a form of "extortion".

Investigations of pecuniary externalities in environmental economics often focus on indirect effects. The debate over the indirect effects of biofuel subsidies provides a template for considering some of the ways relative price changes may be included in policy design. Zilberman et al. (2011) examine the impact of biofuel subsidies on indirect land use change through increased food prices, and they begin by noting the validity of considering pecuniary externalities in policy design. In Zilberman et al (2011) and other studies such as Zilberman et al. (2013) a similar group of authors cast doubt on the inclusion of indirect land use change in biofuel subsidy planning largely because of the myriad other indirect effects that add to uncertainty and which should also be included, in an ideal world.

2.3. *Environmental Justice*

Improved environmental quality can lead to gentrification, displacing lower income households that tend to rent rather than own their homes (Banzhaf et al 2019).

3. METHODS

3.1. *Long Run Dynamics*

In this section, we develop a dynamic model of a firm and a household who can buy/sell and rent a unit of housing that is a bundle of attributes, z, and q, the attribute of interest which we might imagine is an environmental amenity such as clean air. We assume that the firm and the household trade in competitive markets with perfect knowledge aside from an unexpected shock, discussed below. We assume that the firm is profit maximizing and the household or consumer is utility maximizing. The firm and the household make decisions at each time period to buy/sell and to rent. We focus our analysis on a typical housing unit which may be owned by different firms and rented by different households each year. Notably, in empirical applications, market activity for hedonic assets like houses works in this manner and capitalized values related to housing are the result of expected interactions between households and firms with probabilities of buying/selling and renting/moving that are generally strictly between zero and one. The non-zero probability of moving that renters face each time period is built into consumer decision making and is thus reflected by housing prices. The household and the firm interact at the beginning of each time period when the household pays rent. The transaction is the result of the household maximizing the present value of their utility. Included in the household's first order conditions would be the The firm purchases a house at time t for P_t borrowed at interest rate r. Later, at $t + 1$, the firm sells the house for P_{t+1} and repays the loan plus interest, $(1 + r)P_t$. After purchasing the house, the firm rents out the unit of housing to a household for, R_t and pays costs C_t.

The present value of the producer's profit for a single time period (assuming no fixed costs) will be,

$$\pi_t = (R_t - C_t) + \left(\frac{P_{t+1}}{1+r} - \frac{P_t(1+r)}{1+r} \right). \tag{1}$$

Where the first term is the net revenue from rent and costs for the time period and the second term represents the present value of house price returns and the principle plus the interest payment on P_t.

Over the same time period, a household rents the house for R_t and has a willingness to pay $WTP_t = WTP(q_t, z_t, y)$ for that housing unit. We can assume that there is an equilibrium rent function, $R_t = R(q_t, z_t, P_t, C_t)$ and that $WTP_t \geq R_t$. One might estimate this function using the hedonic price method and time series rent data, though as we will show this is not necessary. At the end of the time period, the consumer's monetized benefit is:

$$w_t = WTP_t - R_t$$

Here we can see that optimization will result in a first order condition that reveals marginal willingness to pay for a single point on the household's demand curve for housing in time period, t,

$$\frac{\partial WTP_t}{\partial q_t} = \frac{\partial R_t}{\partial q_t} \tag{2}$$

Returning to the firm, if we assume the market uses information to price houses efficiently, today's price will equals tomorrow's price,

$$P_t = P_{t+1}.$$

Future work might consider relaxing this assumption by incorporating the impacts of a stochastic specification and including short run macroeconomic effects. We can rewrite the profit equation in 1 as,

$$\pi_t = (R_t - C_t) - P_t * \frac{r}{1+r}. \tag{3}$$

Further, if we assume $\pi_t = 0$ and rearrange to solve for the equilibrium rent,

$$R_t = C_t + P_t * \frac{r}{1+r}. \tag{4}$$

Which says that over a time period rent is equal to costs during the time period plus the present value of the interest payment on the cost of the house as capital. If rent were lower than this value, profits would be negative, firms would exit, house prices would fall, and the interest payments and other costs would decline until profits were no longer negative. For each housing unit we can characterize the total welfare, W_t associated with owning and renting the house for a time period,

$$\begin{aligned} W_t &= w_t + \pi_t, \\ &= WTP_t - R_t + 0. \end{aligned}$$

3.2. *Assessing a Shock*

We define a treatment that happens at the end of t_0 that causes q to increase uniformly such that $\Delta q_t = q'_t - q_t > 0$ for $t > 0$. For consumers the alternate welfare measure based on willingness to pay for the higher amenity level, $WTP(q'_t, z_t, y) = WTP'_t$, and an adjusted equilibrium rent, $R'_t = R(q'_t, z_t, P'_t, C'_t)$ is,

$$w'_t = WTP'_t - R'_t \text{ for } t > 0$$

The difference between the treated and untreated states for the consumer is,

$$\begin{aligned} \Delta w_t = w'_t - w_t &= WTP'_t - WTP_t - (R'_t - R_t) && (5) \\ &= \Delta WTP_t - \Delta R_t && (6) \end{aligned}$$

For the producer's alternative profit in the treated state of reality we write,

$$\pi'_t = (R'_t - C'_t) + \left(\frac{P'_{t+1}}{1+r} - \frac{P'_t(1+r)}{1+r} \right) \text{ for } t > 0.$$

which can be simplified in the manner of 3 by assuming competition returns profits to zero and markets function efficiently,

$$\pi'_t = (R'_t - C'_t) - P'_t * \frac{r}{1+r} \text{ for } t > 0. \tag{7}$$

The difference between the treated and untreated states for the producer is zero in all subsequent periods due to the effects of competition, but in the period where the treatment occurs,

$$\Delta\pi_0 = \frac{P_1' - P_0}{1+r} = \frac{\Delta P_1}{1+r} \tag{8}$$

Now we can calculate the present value of the change in total welfare due to the treatment, ΔW_{PV},

$$\begin{aligned}\Delta W_{\text{PV}} &= \Delta\pi_0 + \sum_{t>0} \Delta w_t \\ &= \frac{\Delta P_1}{1+r} + \sum_{t>0} (\Delta\, WTP_t - \Delta R_t)(1+r)^{-t}\end{aligned} \tag{9}$$

This is an intriguing result that helps refine how we compute the distribution of benefits from public projects that enhance amenities. The house price return is an unexpected profit, enjoyed by the owner. This benefit is immediate and has a clear value, while the sign on the individual differences in the sum of future consumer benefits is indeterminate. This result may seem inconsistent with the usual measure of welfare change, such as in Freeman, Herriges, and Kling (2014) and Banzhaf (2020), but next we consider the pattern of changing rent that accompanies the change in price to derive a more familiar measure.

While $\Delta\pi_t = 0$ for $t > 0$, it is still helpful to consider the equation for the change in profits because it can help us understand how rents will change,

$$\begin{aligned}\Delta\pi_t &= \Delta R_t - \Delta C_t - \Delta P_t \left(\frac{r}{1+r}\right) = 0 \text{ for } t > 0 \\ \Delta R_t &= \Delta C_t + \Delta P_t \left(\frac{r}{1+r}\right) \text{ for } t > 0\end{aligned} \tag{10}$$

Returning to our measure of welfare change in equation 9, we can substitute for ΔR_t from 10 and rearrange,

$$\begin{aligned}\Delta W_{\text{PV}} &= \frac{\Delta P_1}{1+r} + \sum_{t>0} (\Delta\, WTP_t - \left(\Delta C_t + \Delta P_t \left(\frac{r}{1+r}\right)\right))(1+r)^{-t} \\ &= \frac{\Delta P_1}{1+r} + \sum_{t>0} (\Delta\, WTP_t - \Delta C_t)(1+r)^{-t} - \frac{\Delta P_1}{1+r}\end{aligned}$$

$$= \Delta WTP_{\text{PV}} - \Delta C_{\text{PV}} \tag{11}$$

Which is the dynamic counterpart to the usual welfare measure. It is important to note that this measure does not convey the imbalanced flow of benefits to the owner and the renter. Indeed, because the public policy that improved the amenity was targeting consumers who would directly benefit, it is a pecuniary externality that competition among renters allows the homeowner to capture a large share of the benefits through rising rent that propels a rising asset value.

3.3. *Marginal Effects*

We are ultimately interested in understanding the relationship between price changes and welfare measures. In the usual approach that is static and does not distinguish between owner and renter, consumer optimization leads to a first order condition, $\frac{\partial WTP}{\partial q} = \frac{\partial P_h}{\partial q}$, which is the theoretical result that connects observable prices to WTP. I take a similar approach using the dynamic model described above, but with an infintesimally small treatment, $\partial q_{t>0}$ applied to all future time periods. I rely on the first order condition in equation 2 from the renter's optimal choice to reveal information about the consumer's marginal willingness to pay for q,

$$\begin{aligned} \frac{\partial WTP_{\text{PV}}}{\partial q_{t>0}} &= \sum_{t>0} \frac{\partial WTP_t}{\partial q_t}(1+r)^{-t} \\ &= \sum_{t>0} \frac{\partial R_t}{\partial q_t}(1+r)^{-t} \\ &= \sum_{t>0} \frac{\partial C_t}{\partial q_t}(1+r)^{-t} + \frac{r}{1+r}\sum_{t>0} \frac{\partial P_t}{\partial q_t}(1+r)^{-t} \end{aligned} \tag{12}$$

Which can be rearranged to help us understand the partial derivative of the price function,

$$\frac{\partial P_1}{\partial q_{t>0}} = \frac{\partial WTP_{\text{PV}}}{\partial q_{t>0}} - \frac{\partial C_{\text{PV}}}{\partial q_{t>0}} \tag{13}$$

If we assume that costs do not change, then we have the standard tangency condition used in the static ownership literature.

3.4. *Owners Who Rent*

If we consider owners who rent to themselves, we can consider the effects on the market of increased wealth. If we consider the willingness to pay function and assume that increases in wealth translate to smooth increases in consumption in perpetuity, then income becomes a function of attriutes of the house, such as q,

$$WTP(q_t', z_t, y(q_t')) = WTP_t^{owner} \text{ for } t > 0 \tag{14}$$

$$WTP(q_t', z_t, y + \Delta P_1 * r) = WTP_t^{owner} \text{ for } t > 0 \tag{15}$$

We can consider the marginal welfare measure for this market of owner-renters,

$$\frac{\partial WTP_{\mathrm{PV}}^{owner}}{\partial q_{t>0}} = \sum_{t>0} \frac{\partial WTP_t^{owner}}{\partial q_t}(1+r)^{-t} \tag{16}$$

we can return to 16 and also assume $\partial WTP_t / \partial y_t = \lambda$, where λ is constant over time and write

$$\frac{\partial WTP_{\mathrm{PV}}^{owner}}{\partial q_{t>0}} = \sum_{t>0} \frac{\partial WTP_t}{\partial q_t}|_{\partial y=0} * (1+r)^{-t} + \sum_{t>0} \frac{\partial WTP_t}{\partial y_t} * \frac{\partial y_t}{\partial q_t}(1 + r^{-t}) \tag{17}$$

$$= \sum_{t>0} \frac{\partial WTP_t}{\partial q_t}|_{\partial y=0} * (1+r)^{-t} + \sum_{t>0} \frac{\partial WTP_t}{\partial y_t} * \frac{r}{1+r} * \frac{\partial P_t}{\partial q_t}(1 + r^{-t})$$

$$= \frac{\partial WTP_{\mathrm{PV}}}{\partial q_{t>0}} + \frac{\lambda}{1+r} * \frac{\partial P_1}{\partial q_{t>0}} \tag{18}$$

Where we have used $\frac{\partial y_t}{\partial q_t} = \frac{\partial \pi_t}{\partial q_t}$. Next, the first term in the right hand side of 18 describes the renter's experience in the rental marketplace (whether or not they are an owner), so we can solve equation 13 for marginal WTP and substitute it into the first term of 18,

$$\frac{\partial WTP_{\mathrm{PV}}^{owner}}{\partial q_{t>0}} = \frac{\partial C_{\mathrm{PV}}}{\partial q_{t>0}} + \frac{\partial P_1}{\partial q_{t>0}} + \frac{\lambda}{1+r} * \frac{\partial P_1}{\partial q_{t>0}} \tag{19}$$

which can be rearranged to highlight the relationship between marginal willingness to pay and marginal sale price for permanent changes in an amenity,

$$\frac{\partial P_1}{\partial q_{t>0}} = \left(\frac{\partial WTP^{owner}_{\mathrm{PV}}}{\partial q_{t>0}} - \frac{\partial C_{\mathrm{PV}}}{\partial q_{t>0}}\right)\left(\frac{1+r}{1+r+\lambda}\right) \tag{20}$$

Next we decompose the partial derivative for the owner's WTP using 18 to show the relative impact on marginal price of homeownership,

$$\frac{\partial P_1}{\partial q_{t>0}} = \left(\frac{\partial WTP_{\mathrm{PV}}}{\partial q_{t>0}} + \frac{\lambda}{1+r} * \frac{\partial P_1}{\partial q_{t>0}} - \frac{\partial C_{\mathrm{PV}}}{\partial q_{t>0}}\right)\left(\frac{1+r}{1+r+\lambda}\right) \tag{21}$$

$$= \left(\frac{\partial WTP_{\mathrm{PV}}}{\partial q_{t>0}} - \frac{\partial C_{\mathrm{PV}}}{\partial q_{t>0}}\right)\left(\frac{1+r}{1+r+\lambda}\right) + \frac{\lambda}{1+r+\lambda} * \frac{\partial P_1}{\partial q_{t>0}} \tag{22}$$

$$= \left(\frac{\partial WTP_{\mathrm{PV}}}{\partial q_{t>0}} - \frac{\partial C_{\mathrm{PV}}}{\partial q_{t>0}}\right)\left(\frac{1+r}{1+r+\lambda}\right)^2 \tag{23}$$

For the owner-renter When the owner-renter is choosing the optimal location, there is no change in profits, so the tangency condition in equation 2 implied by a utility maximizing renter is not affected by ownership. However, an increase in q such as a shock or treatment that affects the buyer's WTP does affect the owner's profits. This leads to the situation where the marginal price under-estimates the benefit of the amenity change to owner-renters. Importantly, because an owner-renter's decision about where to rent does not influence the profits from homeownership, the wealth impacts on price that result from this are smaller than otherwise.

Next, we need to connect $\partial WTP_t/\partial y_t$ to the price function...?? Or can we use data to estimate lambda by modeling the difference in marginal prices for owners and renters?

3.5. *set aside*

Now if we consider a market of only owner-renters

$$\Delta w_t = w'_t - w_t = WTP'_t - WTP_t - (R'_t - R_t) \tag{24}$$

$$= \Delta WTP_t - \Delta R_t \tag{25}$$

If we consider a single year,

$$\begin{aligned}\frac{\partial WTP_t^{owner}}{\partial q_t} &= \frac{\partial WTP_t^{owner}}{\partial q_t}|_{\partial y=0} + \frac{\partial WTP_t^{owner}}{\partial y_t} * \frac{\partial y_t}{\partial q_t} \\ &= \frac{\partial WTP_t^{owner}}{\partial q_t}|_{\partial y=0} + \frac{\partial WTP_t^{owner}}{\partial y_t} * r * \frac{\partial P_t}{\partial q_t} \\ &= \frac{\partial R_t}{\partial q_t} \\ &= \frac{\partial C_t}{\partial q_t} + \frac{r}{1+r}\frac{\partial P_t}{\partial q_t}\end{aligned}$$

allowing us to write,

$$\frac{\partial C_t}{\partial q_t} + \frac{r}{1+r}\frac{\partial P_t}{\partial q_t} = \frac{\partial WTP_t^{owner}}{\partial q_t}|_{\partial y=0} + \frac{\partial WTP_t^{owner}}{\partial y_t} * r * \frac{\partial P_t}{\partial q_t} \tag{26}$$

$$\frac{\partial P_t}{\partial q_t} * \left(\frac{r}{1+r} - \frac{\partial WTP_t^{owner}}{\partial y_t} * r\right) = \frac{\partial WTP_t^{owner}}{\partial q_t}|_{\partial y=0} - \frac{\partial C_t}{\partial q_t} \tag{27}$$

4. DISCUSSION

) Extending the work of **?** to distinguish between owners and renters in a dynamic, general equilibrium framework would be an interesting extension of this work.

REFERENCES

BANZHAF, S. (2020): "Panel Data Hedonics Rosen's First Stage as a "Sufficient Statistic," *International Economic Review*, 61(2), 973-1000d. [8]

BANZHAF, S., MA, L. AND TIMMINS, C. (2019): "Environmental Justice: The Economics of Race, Place, and Pollution," *Journal of Economic Perspectives*, 33(1), 185-208. [ ]

BISHOP, K.C., KUMINOFF, N.V., BANZHAF, H.S., BOYLE, K.J., VON GRAVENITZ, K., POPE, J.C., SMITH, V.K. AND TIMMINS, C.D., (2020): "Best practices for using hedonic property value models to measure willingness to pay for environmental quality," *Review of Environmental Economics and Policy*, 14(2), 260-281. [ ]

BISHOP, K.C. AND MURPHY, A.D. (2011): "Estimating the Willingness to Pay to Avoid Violent Crime: A Dynamic Approach," *American Economic Review*, 101(3), 625-629. [ ]

Bishop, Kelly C., and Alvin D. Murphy. "Valuing time-varying attributes using the hedonic model: when is a dynamic approach necessary?." Review of Economics and Statistics 101, no. 1 (2019): 134-145.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Buchanan, J.M. and Stubblebine, W.C., 1962. Externality. In Classic papers in natural resource economics (pp. 138-154). Palgrave Macmillan, London.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Bui, L.T. and Mayer, C.J., 2003. Regulation and capitalization of environmental amenities: evidence from the toxic release inventory in Massachusetts. Review of Economics and statistics, 85(3), pp.693-708.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Dávila, E. and Korinek, A., 2018. Pecuniary externalities in economies with financial frictions. The Review of Economic Studies, 85(1), pp.352-395.,

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

FREEMAN, A.M. (1987): *The Measurement Of Environmental And Resource Values: Theory And Methods*. Washington DC, U.S.A.: Resources for the Future. [ ]

FREEMAN III, A. MYRICK, JOSEPH A. HERRIGES, AND CATHERINE L. KLING. (1987): *The Measurement Of Environmental And Resource Values: Theory And Methods*. Washington DC, U.S.A.: Routledge [8]

Holcombe, R.G. and Sobel, R.S., 2001. Public Policy Toward Pecuniary Externalities. Public Finance Review, 29(4), pp.304-325.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Scitovsky, T., 1954. Two concepts of external economies. Journal of political Economy, 62(2), pp.143-151.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Palmquist, R.B., 1989. Land as a differentiated factor of production: A hedonic model and its implications for welfare measurement. Land economics, 65(1), pp.23-28.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Zilberman, D., Barrows, G., Hochman, G. and Rajagopal, D., 2013. On the indirect effect of biofuel. American Journal of Agricultural Economics, 95(5), pp.1332-1337.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

Zilberman, D., Hochman, G. and Rajagopal, D., 2011. On the inclusion of indirect land use in biofuel. U. Ill. L. Rev., p.413.

AUMANN, R. J. (1987): "Correlated Equilibrium as an Expression of Bayesian Rationality," *Econometrica*, 55, 1–18. [ ]

AUMANN, R. J. (1987): “Correlated Equilibrium as an Expression of Bayesian Rationality,” *Econometrica*, 55, 1–18. [ ]

PECK, J. (1994): “Competition in Transactions Mechanisms: The Emergence of Competition,” Unpublished Manuscript, Ohio State University. [ ]

ENELOW, J., AND M. HINICH, eds. (1990): *Advances in the Spatial Theory of Voting*. Cambridge, U.K.: Cambridge University Press. [ ]

WITTMAN, D. (1990): “Spatial Strategies when Candidates Have Policy Preferences,” in *Advances in the Spatial Theory of Voting*, ed. by M. Hinich and J. Enelow. Cambridge, U.K.: Cambridge University Press, 66–98. [ ]

CAHUC, P., F. POSTEL-VINAY, AND J.-M. ROBIN (2006): “Supplement to ‘Wage Bargaining with On-the-Job Search: Theory and Evidence’,” *Econometrica Supplementary Material*, 74. [ ]