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ARTICLES

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BOOK REVIEWS

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BOOK REVIEWS

Farm Efficiency and Its Determinants in Different Farm Size and Altitude Categories: A Case of Organic Coffee Cultivation in Nepal

Krishna Lal Poudel, Bhawani Mishra, and Thomas G. Johnson*

ABSTRACT. Coffee farmers typically operate without knowledge of their actual and potential economic efficiency. Understanding the technical relationships between inputs and outputs is the key to increasing the efficiency of production. This research estimated the level of Technical Efficiency (TE), and the key factors affecting farm level efficiency, of organic coffee cultivation in the hill region of Nepal. TE of 280 organic coffee farms was related to farm size and farm altitude categories. Increasing returns to scale was observed in 43.21% of organic farms suggesting that greater efficiency could be achieved through enlargement. The mean technical efficiencies of small, medium and large farms were 84.7%, 90.7%, and 90.6% respectively and in low, medium and high altitude locations were 89.6%, 86.1% and 91.9% respectively. Approximately 46%, 43% and 39% of the coffee farms in low, medium and high altitude areas were found to be technically efficient. Similarly, about 43%, 50% and 56% of small, medium and large coffee farms respectively were technically efficient. Tobit regression revealed that the variation in technical efficiency was related to education, farm experience and training/extension services. (Q12; Q01; Q15)

I. Introduction

Agriculture and Livestock contribute 38.8 % of Gross Domestic Product (GDP) and provides 65.6% employment in Nepal (MOAC, 2009). Despite the large contribution, the average landholding size is less than 1.0 ha. (CBS, 2010). It also serves as the major sources of raw materials to most of the agro-based industries. Among the agricultural commodities, horticultural crops play a significant role in the agricultural

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development and economic growth of the country. Horticulture contributes 14% of the total agriculture GDP (CBS, 2010). The country is transitioning into intensification, diversification, and commercialization of agriculture crops. To achieve this, the production programs should be market oriented. In order to achieve this the agricultural program seeks to raise AGDP growth from 2.9% to 4.9% at the end of the plan, 2025 (APP, 1995). In the present context of growing economic and trade liberalization, the Nepalese farmers, traders, and other marketing agencies need to be efficient and competitive. Appropriate environment, institutional arrangements and relevant support must be created and provided to promote their effective and sustainable participation to make farming and agribusiness competitive. Since the third periodic plan (1965-1970) government is more attentive to the area of agricultural marketing and price policy. All subsequent plans have continued this focus but the outcomes have not been as hoped. Various types of buying and selling arrangements between the producers and traders are occurring but which mode of transaction is beneficial to the farmers and other actors has not been well explored.

Coffee is one of the high value horticultural cash crops. Coffee has been popular among Nepalese farmers for the last few decades. Coffee cultivation has spread to over 39 districts in the middle hill region of Nepal (NTCDB, 2009). Coffee can be produced commercially in many parts of the country. However, there is great potential in the mid hills region for organic coffee production. This will increase the income of the rural farmers as well as other businesses involved in coffee processing and marketing (ITC, 2007). Coffee plantations cover productive area of 1400 ha with the involvement of more than 5000 farm families (MOAC, 2009).

The Government of Nepal has already given priority to coffee through its long term perspective (APP 1995/96). This crop is economically more (nearly three times) profitable compared to other cereal crops (Bajracharya, 2003). The climate and soil quality is adequately favorable to organic production of coffee in mid hills region of Nepal (Nepal, 2006). Farmers are accelerating the production via converting land to coffee. With the current trend of production and productivity, Nepal will produce about 3290 and 9870 mt dry coffee cherry in 2011 and 2015 AD respectively (Shrestha, 2003). The coffee cultivation area and production is being increased by 24.8% and 18.27% respectively. The growth rate of area and production of organic coffee are

19.39% and 13.39% respectively (MOAC, 2009).

The way to increase profits of small scale farms is to use available resources efficiently. Production economics explains optimization of resources and optimization leads to efficient production. Bravo-Ureta and Reiger (1991) explained that efficiency measurement is important because it leads to a substantial resource savings. Efficiency measurement can be estimated using nonparametric and parametric approaches. Data envelopment analysis (DEA) is a nonparametric method. The nonparametric approach does not impose any parametric restrictions on technology and there is no need for a functional form for production relationships and is thus considered more flexible to calculate efficiencies (Ray, 2004). This study will explain efficient production planning in different altitude ranges and different landholding sizes of coffee farms.

II. Study area, sampling, data and variables

This study is an extension of earlier research done by Poudel et al. (2015) which compared organic and conventional coffee farming in the hill region of Nepal. The current study makes efficiency comparisons for farms in three different altitudes and landholding size categories using more observations (n=280) than in the previous study, and focuses on organic farms only. Gulmi district is in the western mid-hill region of Nepal and the only certified organic Arabica coffee producing district in Nepal. In this district coffee is produced at altitudes above 800 meters. Since 1998, all farms in this region have been certified by NASAA[1]. Group certification of this sort requires that members all maintain internal control systems (ICS[2]). The information is collected from 280 households out of 391 households from 12 Village Development Committee (VDC[3]) of Gulmi district.

The VDCs selection was purposive to ensure the diversity in farm acreage and altitude range. Research envisaged understanding the economic differences in respect to variation in farm size and altitude. These selected VDCs are predominantly coffee producing and have similar topography, soil type and irrigation environments. The surveyed areas ranged between 800 to 1410 m above sea level. Organic farms were classified according to farm size and farm altitudes. A farm with planted coffee areas of less than 10 ropani (n=186), less than 20 ropani (n=62) and 20 ropani or greater (n=32) were classified as small, medium and large size farm respectively. Likewise, a farm located in 800-1000 meter (n=76), 1001-1200 meter (n=132) and 1201-1400 meter (n=72) or more were classified as low, medium and high altitude farm respectively.

TABLE 1. Variable definition and measurement

Variables	Unit	Defnitions (...for farm j)
Farm size (X_{1j})	Ropani*/farm	Area of the organic coffee farm
Labor (X_{2j})	Man days/farm	Total number of labor employed for coffee production
Fertilizer (X_{3j})**	Rs/farm†	Cost incurred for organic fertilizer in coffee production
Capital (X_{4j})	Rs/farm†	Pesticides, equipment and irrigation devices etc.
Output (Q_{1j})	Kg/farm	Quantity of green bean produced
Inter/shade crops (Q_{2j})	Rs/farm†	Value of intercrops and shade crops in coffee farm
Coffee tree (Q_{3j})	Number	Total number of fruit bearing coffee trees
Household size (Z_{1j})	No. of persons	Number of individuals in a family
Education (Z_{2j})	1,0	1 if the farm manager is literate, 0 otherwise
Sex (Z_{3j})	1,0	1 if the farm manager is male, 0 otherwise
Training/Extension (Z_{4j})	1,0	1 if the farm manager received training, 0 otherwise
Age (Z_{5j})	Year	Age of farm manager
Farm Experience (Z_{6j})	Year	Years of coffee cultivation
Labor cost (X_{5j})	Rs/person-day	Labor cost during production management

*One Ropani = 511.14291 m^2. **Farm Yard Manure (FYM), †As variables X_3, X_4, X_5, and Y_2 are expressed in value terms and measured in local currency unit. Rs, Rupees, a Nepalese currenty and Rs1 = \$US (1/74).

Primary data were obtained through face-to-face interviews with pre-tested semi-structured questionnaires in January to May 2011 and February to April 2012. Besides, Rural Participatory Appraisal (PRA) tools such as Focus Group Discussion (FGD) and Key Informant Survey (KIS) were also deployed to assess and observe general understanding that were not captured in questionnaire. The secondary data were used from the publication of Ministry of Agriculture and Cooperative (MOAC). The detail of notations and definitions of variables used in the analysis are shown in Table 1.

III. Analytical Framework

To achieve productivity growth, either technological innovation or the more efficient use of available technologies or a combination of both is inevitable. Empirical evidence suggests that small farms are desirable not only because they reduce unemployment, but also because they provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy (Bravo-Ureta and Pinheiro, 1997). During the last few decades, major technological gains stemming from the green revolution have been effective across the developing world. This suggests that attention to productivity gains arising from a more efficient use of existing technology is justified. In developing countries, most new agricultural technologies have only been partially successful (Xu and Jeffrey, 1998). It will be more cost effective to motivate farmers in improving efficiency rather than grafting new technology if farmers are not efficiently using existing technology (Belbase and Grabowski, 1985). TE defined as the ability of a farm to either produce the maximum possible output from a given set of inputs and a given technology, or to yield the given level of output from the minimum possible quantity of inputs. Färe and Lovell (1978) defined technical efficiency as the "degree to which the actual output of production unit approaches its maximum". Färe et al. (1994) have proposed the input oriented DEA approach to illustrate TE via linear programming (LP) method. Farrell (1957) proposed this piece-wise-linear convex hull approach to frontier estimation. This paper used DEA in constant return to scale (CRS) model. Assuming that, the farm is assumed to have N inputs and M outputs for each of I farms. Inputs and output vectors of i^{th} firm then becomes N*I input matrix of **X** and M*I output matrix of **Q**. Ratio of output to overall inputs is estimated under DEA approach by assigning optimal weights by solving a mathematical programming problem. We followed Coelli et al. (2005) in formulating the solving equation and we used DEA Excel Solver 2.0 computer program. Here, u= M*I vector of output weights and v= N*I vector of input weights.

$$
\begin{aligned}
&\max_{u,v} && [\mathbf{u}'\mathbf{q}_i/\mathbf{v}'\mathbf{x}_i] \\
&\text{st} && [\mathbf{u}'\mathbf{q}_j/\mathbf{v}'\mathbf{x}_j] \leq 1, \quad j = 1,2, \ldots, I, \\
& && \mathbf{u}, \mathbf{v} \geq \mathbf{0}
\end{aligned}
\tag{1}
$$

Equation (1) involves solving for u and v, such that the efficiency measures for the i^{th} firm is maximized subject to the constraints that efficiency value be less than or equal to 1. To overcome the problem of infinite number of solutions from this specific ratio formulation, we impose the constraint $\mathbf{v}'\mathbf{x}_i = 1$, then

$$
\begin{aligned}
&\max_{\mu,v} && [\boldsymbol{\mu}'\mathbf{q}_i] \\
&\text{st} && \mathbf{v}'\mathbf{x}_i = 1, \\
& && \boldsymbol{\mu}', \mathbf{q}_j - \mathbf{v}'\mathbf{x}_j \leq 0, \quad j = 1,2, \ldots \ldots, I, \\
& && \boldsymbol{\mu}, \mathbf{v} \geq \mathbf{0},
\end{aligned}
\tag{2}
$$

Where the change of notation from u and v to μ and V is used to stress that this is a different linear programming problem. The problem formulated in (2) is known as the multiplier form. Finally the derivation of an equivalent envelopment by introducing the duality in linear programming is:

$$
\begin{aligned}
& && \min_{\theta i\lambda}, \theta_i \\
&\text{st} && -\mathbf{q}_i + \mathbf{Q}\boldsymbol{\lambda} \geq \mathbf{0}, \\
& && \theta\mathbf{x_i} - \mathbf{X}\boldsymbol{\lambda} \geq \mathbf{0}, \\
& && \boldsymbol{\lambda} \geq \mathbf{0},
\end{aligned}
\tag{3}
$$

Where λ is a I*1 vector of constant, θ is a scalar and efficiency scores for the ith firm which satisfies: $\theta \leq 1$. Here θ is independent of input prices.

Charnes et al. (1994) and Färe et al. (1994) used this input oriented DEA model under CRS assumption to solve the overall technical efficiency. Farm specific factors responsible for technical inefficiency were measured through the second stage regression model. This sort of analysis was found in Dhungana (2010), Dhungana (2004), Wadud and

White (2000), Sharma et al. (1999), Wang et al. (1996) and, Hallam and Machado (1996). Early methodologies were based on deterministic models that attribute all deviations from the maximum production to efficiency; recent advances have made it possible to separately account for factors beyond and within the control of firms such that only the latter will cause inefficiency. The popular approach to measure the technical efficiency component is the use of frontier production function (Wadud and White, 2000 and Sharma et al., 1999). The present study employed the empirical model,

$$TE^* = \beta_0 + \beta_1 Z_{1j} + \beta_2 Z_{2j} + \beta_3 Z_{3j} + \beta_4 Z_{4j} + \beta_5 Z_{5j} + \beta_6 Z_{6j} + u_i \qquad (4)$$

$$\begin{cases} TE^* & \text{if } TE^* < 100 \\ 100 & \text{otherwise} \end{cases}$$

Where TE is efficiency index from DEA which was used as binary dependent variable. Z_1, Z_2, Z_3, Z_4, Z_5 and Z_6 were household size, education, sex, training/extension, age and farm experience respectively. β is a vector of unknown parameters, u_i is an independently and identically distributed normal random variables with zero means and common variances, σ^2 as; $u_i \sim$ iidN $(0, \sigma^2)$. It is noted that the dependent variable has a censored distribution (as TE lies between 0 and 100) and does not have normal distribution. Because OLS yields inconsistence estimates, we followed maximum likelihood approach to estimate the parameters of tobit regression model (equation 4) using SHAZAM 10.0 software.

IV. Results and Discussions

Inputs and outputs, and socio-demographic parameters were considered for empirical analysis. Summary descriptive statistics of socio-economic characteristics of the organic coffee production farms related to farm size and farm altitude are depicted in Table 2 and 3 respectively.

TABLE 2. Socio-economic characteristics of organic farms (Farm size category)

Variables	Small farm (n=186)		Medium farm (n=62)		Large farm (n=32)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farm size (Rop.)	2.90	2.33	12.91	2.60	31.15	13.65
Production/Farm (kg)	39.88	55.05	38.67	85.34	37.09	56.94
Labor cost/Farm (Rs)	2049.19	1617.52	2251.61	2302.29	2406.25	1977.60
Fertilizer cost/Farm (Rs)	3614.89	4631.74	5401.93	10599.37	3460	4092.66
Marketing cost/Farm (Rs)	246.78	314.52	255.12	543.61	237.20	340.14
TVC/Farm (Rs)	6345.5	6435.31	8604.40	14076.08	6587.51	6580.94
GR/Farm (Rs)	9258.9	10014.57	9744.59	15469.66	11990.31	17971.55
GM/Farm (Rs)	2913.4*	6753.45	1140.19*	8986.75	5402.79*	12400.64
Age (yr)	45.32	9.77	47.64	11.07	45.62	10.35
Farm Experience (yr)	11.12***	2.96	9.08***	2.39	8.93***	2.15
Family size (No.)	4.65	1.29	4.58	1.36	4.68	1.30
Education (Lit. %)	94.08		95.16		93.75	
Training/Ext. (%)	77.96		56.45		40.62	

*and*** indicate means are significantly different in F-test at 10% and 1% respectively.
Source: Field survey 2011 and 2012, and author's calculation.

TABLE 3–Socio-economic characteristics of organic farms (Farm altitude category)

Variables	Low (n=76)		Medium (n=132)		High (n=72)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farm size (Rop.)	9.94***	9.56	7.90***	10.44	7.41***	11.40
Production/Farm (kg)	23.47***	25.21	36.27***	65.35	61.62***	78.91
Labor cost/Farm (Rs)	1821.05***	1253.08	2013.63***	1849.52	2684.72***	2178.68
Fertilizer cost/Farm (Rs)	2979.34***	3846.19	3426.66***	7454.69	6106.38***	6127.83
Marketing cost/Farm (Rs)	152.18***	154.30	235.21***	403.92	371.25***	458.63
TVC/Farm (Rs)	5335.86***	5102.41	6177.64***	9924	9771.81***	8903.07
GR/Farm (Rs)	6569.21	4481.737	9385.83	13946.04	13507.29	14325.67
GM/Farm (Rs)	1233.34	4935.90	3208.18	8795.64	3735.47	9407.26
Age (yr)	47.36	10.32	45.27	10	45.63	10.24
Farm experience (yr)	9.36***	2.19	10.12***	2.60	12.08***	3.47
Family size (No.)	4.47	1.47	4.7	1.20	4.69	1.31
Education (Lit. %)	96.05		93.93		93.05	
Training/Ext. (%)	65.78		65.9		77.77	

*, ** and*** indicate means are significantly different in F-test at 10%, 5% and 1% respectively.
Source: Field survey 2011 and 2012, and author's calculation.

The first section of both tables describes farm economic characteristics and lower section socio-demographic information. Observations showed that variations in economic characteristics were more significant in altitude category than farm size category. Most means are significantly different in farm altitude categories at 1% in ANOVA. From Table 2, we observed that average production of organic coffee beans is higher in small farms consuming lower inputs than medium and large size farms in the study areas. The non-discounted benefit cost ratio (B/C ratio) was highest in large farms (1.84), followed by small farms (1.68) and medium farms (1.66) respectively. About 78% of the small growers were receiving training and extension facilities where as 56.45 and 40.62% of farmers received the same in medium and large size farm category.

From Table 3, we observed that average production of coffee is higher in high altitude farms along with higher levels of labor and organic fertilizer consumption than other altitude categories. Gross margin (GM) obtained from high altitude (9407.26) is higher than others and three times greater than low altitude farms.

A. TECHNICAL EFFICIENCY

Technical efficiency ranged from 0.185 to 1.00, 0.400 to 1.00 and 0.467 to 1.00 in low, medium and high altitude respectively (Table 4). Similarly, TE ranged from 0.406 to 1.00, 0.179 to 1.00 and 0.652 to 1.00 in small, medium and large farm size respectively (Table 5). When TE gets closer to one, the farm is considered more technically efficient. Mean technical efficiency in low, medium and high altitude were 84.7%, 90.7% and 90.6% respectively. From the TE distribution series, it would be possible to draw the inference; organic coffee can be increased by about 16%, 10% and 10% in low, medium and high altitude respectively.

About 10, 14 and 9% output could be augmented in small, medium and large farm size respectively if each producer was working on the production frontier. Around 46%, 43% and 39% of the coffee farms in low, medium and high altitude were found technically efficient (Table 4). Likewise, about 43%, 50% and 56% coffee farms were technically efficient in small, medium and large farm size respectively (Table 5).

TABLE 4–Distribution of technical efficiency in different farm size altitude categories in deciles range

Efficiency Level	Low altitude		Medium altitude		High altitude	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
≤0.50	4	5.27	2	1.51	1	1.39
0.51-0.60	4	5.27	1	0.76	1	1.39
0.61-0.70	7	9.21	4	3.03	2	2.78
0.71-0.80	15	19.73	17	12.88	9	12.5
0.81-0.90	8	10.52	33	25	18	25
0.91-1	38	50	75	56.82	41	56.94
Total	76	10	132	100	72	100
Mean	0.847		0.907		0.906	
Std. Dev.	0.183		0.118		0.111	
Minimum	0.185		0.400		0.467	

Source: Field survey 2011 and 2012, and author's calculation.

TABLE 5–Distribution of technical efficiency in different farm size categories in deciles range

Efficiency Level	Small Farm Size		Medium Farm Size		Large Farm Size	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
≤0.50	3	1.61	5	8.06	0	0
0.51-0.60	7	3.76	3	4.84	0	0
0.61-0.70	13	6.99	3	4.84	3	9.38
0.71-0.80	18	9.68	6	9.68	3	9.38
0.81-0.90	39	20.97	10	16.13	58	15.62
0.91-1	106	56.99	35	56.45	21	65.62
Total	186	100	62	100	32	100
Mean	0.896		0.861		0.919	
Std. Dev.	0.135		0.196		0.112	
Minimum	0.406		0.179		0.652	

Source: Field survey 2011 and 2012, and author's calculation.

The estimated mean technical efficiencies in small, medium and large farm sizes were 89.6%, 86.1% and 91.9% respectively. Large farms reached relatively higher technical efficiency even though there can be room for increasing total output by 8.1%. Organic coffee farms operating with more than 80% technical efficiency in low, medium and high altitude were 62.52%, 81.82% and 81.94% respectively (Table 4). While in small, medium and large farm size, the farms reaching the same level of technical efficiency were 77.96%, 72.58% and 81.24% respectively (Table 5). Regardless of category, the farms operating under CRS, DRS and IRS were 46.07%, 10.72% and 43.21% respectively (Table 6).

The average coffee output in the farms operating under CRS was higher than DRS and IRS. The matrix of farm size and altitude categories revealed that mean TE was higher for large farm size in high altitude, followed by large farm size in low altitude than other cross categories. Lower TE was recorded for medium farm size in low altitude.

TABLE 6–Summary of returns to scale results (n=280) in organic cultivation of coffee.

Characteristics	No. farms	Coffee output (kg/farm)		
		Mean	Min	Max
CRS	129 (46.07)	19.35	0.2	140
DRS	30 (10.72)	15.55	0.83	49.33
IRS	121 (43.21)	10.521	0.1	80

Source: Field survey 2011 and 2012, and author's calculation

B. FARM SPECIFIC FACTORS RELATED TO FARM INEFFICIENCY

The maximum likelihood estimation of determinants of technical efficiency of organic farmers for farm size and farm altitude categories are presented in Tables 7 and 8 respectively. Most of the factors were not significant in small farm size category except gender in farm managerial decision. The coefficients of education, training and age were positive. The factor education is significant in medium size farm while other factors such as training/extension, age and farm experience were significant at 0.1 and 0.05 respectively in large size coffee farms.

Education, training and farming experiences in agricultural enterprises were significant and followed the findings of Dhungana (2010), Inoni (2006) and Dhungana (2004). Farm experience was not significant in small farm size, and low and medium altitude, but had negative sign. This indicates that farmers with more years of experiences do not necessarily place value on producing more output. Insignificant and negative coefficient of age variable in small and medium farm size and in low and high altitude indicated that younger farmers tend to be more productive than aged one. This is consistent with the findings of Llewelyn and Williams (1996), Ajibefun et al. (1996), Seyoum et al. (1998) and Coelli and Battese (1996). Education was significant in medium farm size and high altitude at 1% level of significance. The coefficient of education was positive in all categories except in the medium altitude. This suggests that educated people are more likely to be efficient in applying technical knowhow on crop management and post-harvest management. These sorts of results were discovered in Idiong (2007), Dhungana (2004) and Binam et al. (2004). Similar results were also reported by Moock (1976), Stefanou and Saxena (1988), Ali and Flinn (1989), Parikh et al. (1995), Battese et al. (1996), Wang et al. (1996) and Llewelyn and Williams (1996). In the long run, increasing private and public investment in education might lead to better performance in the agricultural sector (Dhungana, 2004).

Educated farm manager are more efficient than their counterparts, perhaps as a result of their keen interest coupled with better skill to access information and thereby production planning. Similar results were also reported by Minh (2009) and Wang et al. (1996). But Umoh (2006) reported that education does not contribute to farm efficiency in studying urban farming in Nigeria. The estimated coefficient of training/extension facilities was not significant except for large farm size. Coefficient of farm experience were of mixed result such that significant at 1% in medium and large farm size but unexpected sign (negative) in small farm size and low altitude. However, the farm experience in medium and high altitude was positive. These mixed results infer that being an experienced farmer is not enough to reach a farm to attain higher level of efficiency unless a farm manager rearranges the basket of inputs with a given technology.

TABLE 7–Tobit regression analysis

Independent variables (Z_{ij})	Small farm size		Medium farm size		Large farm size	
	β coeff.	t-ratio	β coeff.	t-ratio	β coeff.	t-ratio
Constant	-1.144	-1.948	-0.552	-0.626	-2.964	-2.747
HH size (Z_{1j})	-0.039	-0.572	-0.120	-1.200	0.012	0.088
Education (Z_{2j})	0.147	0.550	0.793	1.402*	0.620	1.054
Sex (Z_{3j})	0.706	2.867*	0.41	0.266	-0.326	-0.554
Training/Extension (Z_{4j})	0.179	0.933	0.115	0.495	0.535	1.792*
Age (Z_{5j})	0.008	0.927	-0.009	-0.760	0.034	2.049**
Farm Experience (Z_{6j})	-0.002	-0.072	0.079	1.404*	0.123	1.524*
Variance of the estimate $(\hat{\sigma}^2)$	1.095		0.810		0.610	
Standard error of the estimate $(\hat{\sigma})$	1.046		0.900		0.781	
Log likelihood function	-184.799		-61.404		-29.847	

***Significant at 1%, ** Significant at 5% and * Significant at 10% level of significance.
Source: Field survey 2011 and 2012, and author's calculation.

TABLE 8–Tobit regression analysis

Independent variables (Z_{ij})	Low altitude		Medium altitude		High altitude	
	β coeff.	t-ratio	β coeff.	t-ratio	β coeff.	t-ratio
Constant	0.237	0.260	-2.424	-3.354	-0.078	-0.061
HH size (Z_{1j})	0.476	0.540	0.121	1.317	0.012	-0.937
Education (Z_{2j})	0.311	0.657	-0.092	-0.300	1.391	1.668*
Sex (Z_{3j})	0.613	1.454*	0.745	2.722***	-0.402	-0.585
Training/Extension (Z_{4j})	0.080	0.331	0.194	0.973	0.129	0.321
Age (Z_{5j})	-0.009	-0.719	0.022	2.054**	-0.014	-0.745
Farm Experience (Z_{6j})	-0.044	-0.617	0.009	0.217	0.023	0.407
Variance of the estimate $(\hat{\sigma}^2)$	0.918		1.110		1.040	
Standard error of the estimate $(\hat{\sigma})$	0.958		1.054		1.019	
Log likelihood function	-74.758		-131.706		-47.707	

***Significant at 1%, ** Significant at 5% and * Significant at 10% level of significance.
Source: Field survey 2011 and 2012, and author's calculation.

V. Conclusion

This study estimates the technical efficiency using DEA approach of organic coffee farms of Gulmi district. It also compares the technical efficiency among different altitudes and different landholding sizes. Results indicated lower technical efficiency on lower altitude and medium farm size. Higher technical efficiency was on higher altitude and large farm size. Overall, 46.07 % of sampled farms were operating under constant return to scale (technically efficient) with mean coffee output of 19.35kg/farm. Tobit regression model produced mixed results in different categories. Most of the factors were not significant in small farm size category except sex. Farmer's sex is significant at 1% in small farm size, low altitude and medium altitude. Education was significant in medium farm size and high altitude at 1% level of significance. The coefficient of education was positive in all categories except in the medium altitude. It could be concluded that educated people are more likely to adopt technical knowhow on farming system management. These results are consistent with other studies such as Mesike et al. (2009) and Dhungana et al. (2010). Since this study specifically identified efficient and inefficient coffee farms, inefficient farms can learn from efficient farms to improve their efficiency in coffee production. Even efficient farms can learn further from their current combination of farms inputs to improve efficiency in the future.

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Endnotes

1. The National Association for Sustainable Agriculture, Australia (NASAA), founded in 1986, supports industry and consumers on organic, biodynamic and sustainable agricultural practices. It works to develop and maintain organic standards; assist operators in gaining organic certification; and conducting ongoing compliance supervision (NASAA 2015).
2. Internal controls systems (ICS) represent standardized rules for operating organic smallholder farms. International Federation of Organic Agriculture Movements (IFOAM) has developed this short summary of the requirements. The rationale for an ICS is to bring down the cost of organic certification to small holders by establishing a group that can do much of the monitoring itself. Certifiers monitor whether the group processes and data collection are working well, and to check a small number (sample) of the farms. After carefully setting up the group and its rules, the regulations can be simplified to such an extent that even illiterate farmers are clear on the rules they must follow, and the data that must be kept, and by whom (IFOAM 2015).
3. VDC is the smallest geopolitical boundary in Nepal

Building an Economic Theoretical Framework to Link Quizzes, Effort Investment, and Learning Outcomes

Tin-Chun Lin*

ABSTRACT. Using an economic theory (theory of producer choice), a basic theoretical model is constructed to illustrate how and why quizzes can affect a student's behavior in effort-investment and learning outcomes. The theoretical evidence demonstrated that quizzes can improve students' exam performance and enhance their investment in effort, and that unannounced-quizzes may most likely increase student in-class effort relative to announced-quizzes; while announced-quizzes may most likely enhance student out-of-class effort relative to unannounced-quizzes. In addition, this study looks at how different types of quizzes may serve as different effective instructional methods for student learning, and seeks to explain why student efforts are suboptimal absent a quiz. More importantly, this study frames an economic theoretical background for quizzes, which can be useful in constructing empirical models for further investigations of this issue. (A20; A22; D20; D21; I20)

I. Introduction

The topic of quizzes has been broadly investigated by a mass of researchers, many of whom are psychologists (e.g., Azorlosa and Renner, 2006; Wilder, Flood, and Stromsnes, 2001). The disciplines of psychology and economics both study human behavior, but with different analytical focuses. Psychologists focus on an individual's perception, cognition, emotion, motivation, etc.; while economists focus on how cost/benefit affect an individual behavior. For example, from the psychological perspective, quizzes motivate students to attend classes; while from the economic perspective, quizzes raise the opportunity cost of missing classes. In order to reduce cost, students attend classes. Although the analytical focuses differ, both predict the same result – students will attend classes more frequently when mandatory quizzes are part of the class plan.

A review of the literature on the extent to which announced versus

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unannounced class quizzes and quizzes versus no quizzes could influence examination results showed that a vast number of studies have been framed using behavioral theories of learning at the individual level, such as reinforcement learning theory or goal-setting theory (e.g., Haigh, 2007; Sansone, Fraughton, Zachary, Butner, and HeinerSelf, 2011; Tremblay, Gardner, and Heipel, 2000). Many recent studies also have specifically examined quizzes as a learning process and their influence on examination results and other learning outcomes (e.g., Landrum, 2000).

Obviously, psychologists have successfully used psychological theories (e.g., learning behavioral theories) at the individual level to frame their studies on the topic of quizzes. However, in designing and preparing for this study, we did not identify a literature that recounted efforts to use economic theories at the individual level to model class quizzes. For that reason, we attempted to use the theory of producer choice[1] to frame a model for quizzes that can be used to present how and why students' investment in efforts and education output would change by taking quizzes. The reason for using economic theory to model class quizzes is that the quiz is one of the factors that may influence a student's effort-investment and hence impact the student's learning outcome, and students can be regarded as producers who produce their knowledge. This idea inspired us to use economic theory to frame a theoretical background for quizzes and in turn to describe students' investment behavior in efforts to produce knowledge.

This issue is important because educators need to comprehend students' investment behavior in accumulating their human capital. A student's human capital investment not only includes monetary investment (e.g., tuition) but also includes effort investment (e.g., time devoted to studying for classes). Since quizzes are one of the important factors affecting a student's effort investment, this paper particularly focuses on a student's investment in effort. Therefore, we developed five research questions for this study: (1) Do quizzes enhance students' investment in effort? (2) Do quizzes improve students' learning outcomes? (3) Do different types of quizzes influence students' behavior differently in in/out-of-class effort investment? (4) Would different types of quizzes serve different effective instructional purposes in students' learning? (5) Why are student efforts suboptimal absent a quiz?

In short, the main contribution of this paper is that it offers the first descriptive look at the use of producer choice theory to model class quizzes, linking the economic relationship among quizzes and education output, in-class effort, and out-of-class effort, which may be useful in constructing empirical models for further investigations of this issue.

II. Brief Literature Review

As mentioned earlier, this paper recounts an economic theoretical study that is the first to use the theory of producer choice to frame the topic of class quizzes. No previous study directly relates to our present study. However, a vast number of previous empirical studies are indirectly related to our study. For that reason, in this section, we briefly review some selected previous empirical studies that are related to this topic. Our brief review focuses on the empirical results reported by those previous researchers. We are not able to review the methodology they used, since their studies did not involve an economic theoretical analysis.

According to our research, not all studies have shown that quizzes exert a positive and significant effect on exam performance (e.g., Lumsden, 1976; Conard, Spenser, and Semb, 1978; Beaulieu and Utecht, 1987; Beaulieu and Frost, 1989; Gurung, 2003; and Gaizzi, 2010), but a number have revealed that quizzes have positive and significant effects on exam performance and/or effort investment (e.g., Hovell, Williams and Semb, 1979; Wilder, Flood, and Stromnes, 2001; Azorlosa and Renner, 2006; Azorlosa, 2011 and 2012; Braun and Sellers, 2012; Rusico, 2001; Marchant, 2002; Turney, 1931; Geist and Soehren, 1997; Graham, 1999; Landrum, 2007; and Kamuche, 2005 and 2007).

In addition to exam performance, quizzes serve as an important instructional method for enhancing students' attendance (in-class effort). The studies done by Hovell, Williams and Semb (1979), Azorlosa and Renner (2006), and Braun and Sellers (2012) are examples of those that have shown positive relationships between frequent quizzes and high attendance, inferring that students' attendance is promoted by quizzes. That is, in order to reduce grade loss, students attend class more frequently. The results of Braun and Sellers' (2012) empirical survey even showed that daily quizzes motivated student participation in class discussions.

Moreover, quizzes serve as another important instructional method to augment students' preparation prior to exams (out-of-class effort). For example, Ruscio (2001), Marchant (2002), and Azorlosa and Renner (2006) all found that students in the quiz section would study a few more hours a week than students in the non-quiz section. In addition, Braun and Sellers (2012) revealed that daily quizzes increased students' reading prior to an exam. These examples demonstrated that students' out-of-class effort was improved by the inclusion of quizzes on the syllabus.

Furthermore, researchers even found that quizzes can serve as an effective feedback mechanism. For instance, both Metha (1995) and Bell (1996) showed that quizzes offered instructors instant responses from students. That is, instructors can instantly assess student learning from class quizzes.

III. The Model

3.1. The Knowledge/Grade Production Function

In this study we assumed that each student is a knowledge maximizer. Consider that a student pursues knowledge (denoted by Q). The knowledge production function includes three factors: the student's lecture attendance (i.e., in-class effort, denoted by E), and his/her study outside the classroom (i.e., out-of-class effort, denoted by S), and the instructor's instructional skills/school environment (denoted by I). Both lecture attendance (E) and study outside the classroom (S) are factors that can be determined by the student; thus, these two factors are endogenous variables. Teacher's instructional skills/school environment (I) is the factor that cannot be determined by the student, so this factor is an exogenous variable. Therefore, the knowledge production function can be expressed as: $Q = Q(E,S; I)$, and Q_E, $Q_S > 0$; Q_{EE}, $Q_{SS} < 0$; and $Q_{ES} = Q_{SE} > 0$. Suppose that professors do not inflate students' grades; hence, the level of knowledge acquired is positively reflected in students' grades.[2] In other words, without grade inflation, professors give students grades based upon how much knowledge they acquire.[3] For that reason, a knowledge maximizer can be regarded as a grade maximizer. Therefore, grade (denoted by G) is a function of knowledge, i.e., $G = G(Q)$, and $\frac{dG}{dQ} > 0$. The grade function now is written as: $G = G(E,S; I)$, and G_E, $G_S > 0$; G_{EE}, $G_{SS} < 0$; and $G_{ES} = G_{SE} > 0$.

3.2. The Price Function of In-Class Effort

An opportunity cost of devoting effort to the classroom is the price of attending class (i.e., the price of in-class effort, denoted by P_E). The price of attending class is influenced by the percentage of the course grade for each quiz (denoted by q). When more weight is given to each quiz (say from 0% to 5%) by the professor, if students miss a quiz due to skipping the class, they will lose 5% on their final course grades. Therefore, the opportunity cost of missing class becomes more expensive. Since "missing class" is the opposite of "attending class", the opportunity cost of attending class becomes cheaper $(i.e., \frac{dP_E}{dq} < 0)$. An alternative explanation is that as the weight given to each quiz increases from 0% to 5%, in order not to lose 5% on his/her final course grade, students will attend class more frequently. This implies that the price of attending class becomes cheaper so that students can employ more "attendance" due to the greater weight given to each quiz.

The price of attending class is also influenced by uncertainty (denoted by u), such as an unannounced-quiz. Unannounced-quizzes are short tests given without prior warning or announcement; absent students cannot take unannounced-quizzes later no matter what their reasons for missing class.[4] Hence, when the degree of uncertainty is higher (say from announced to unannounced), if students miss a quiz due to absence, they will lose 5% on their final course grades (assume each unannounced-quiz also = 5% of final course grade). As a result, the opportunity cost of missing class becomes more expensive, implying that the opportunity cost of attending class becomes cheaper $(i.e., \frac{dP_E}{d\theta} < 0)$. An alternative explanation can be expressed as shown below. When the degree of uncertainty given to each quiz increases from announced to unannounced, in order not to lose 5% on his/her final course grade, students will attend class more often. This infers that the price of attending class drops so that students can employ more "attendance" because of the higher degree of uncertainty ascribed to quizzes.

Moreover, the price of attending class can be affected by a student's quality (denoted by θ). The higher the student's quality, the lower the opportunity cost of devoting effort toward the classroom $(i.e., \frac{dP_E}{d\theta} < 0)$. A higher-quality student normally grasps lectures in class more quickly than a lower-quality student. For example, a higher-quality student understands 100% of the lecture in class (say in an hour), while a lower-quality student understands only 50% of the lecture in class. If we quantify the knowledge, then the higher-quality student produces one unit of knowledge in an hour, while the lower-quality student only produces one-half unit of knowledge in an hour. In order to produce one unit of knowledge, the lower-quality student needs double the time to produce it. Suppose that the price of one unit of time is $10—it will cost $20 for the lower-quality student to produce one unit of knowledge, which raises the cost. Therefore, the lower-quality student has a higher opportunity cost of devoting effort in the classroom than the higher-quality student does.

The price of attending class also can be affected by a student's motivation to learn and interest in the class (denoted by λ). The greater the student's motivation to learn and be interested in the class, the lower the opportunity cost of attending class $(i.e., \frac{dP_E}{d\lambda} < 0)$. If a student is very interested in the class and is more motivated to learn the course since he/she plans to go to graduate school, the student usually will grasp lectures in class more quickly than a student who is not interested in the class and is less motivated to learn the course since he/she just wants to pass the class and get a degree. This is because the more motivated student will always concentrate in class and take good notes; while the less motivated student may be frequently distracted in class (e.g., falling asleep or texting in class) and never take good notes. As a result, based upon the reason expressed above for the influence of student quality on price, the opportunity cost of devoting effort in the classroom is relatively lower for the highly motivated student than for the one lacking interest in the class and having a lower motivation to learn the course material.

Moreover, whether or not a student's employment hours (denoted by *h*) may affect his/her attendance is debatable. People who support the no influence on attendance argument believe that if the student can enroll in the class, then the student's work schedule does not conflict with the class schedule. Thus, work hours will not affect the price of attending class. On the other hand, people who support an influence on attendance argument indicate that the more work hours the student works for pay, the less time the student has for travel to campus and for rest, so that the student may skip class more often. Therefore, they believe that the more hours the student works for pay, the higher the price of attending class and the more the student will pay $(i.e., \frac{dP_E}{dh} > 0)$. In this study, we chose the latter argument.

In summary, the price of in-class effort is a function of the percentage of the course grade for quizzes (q), uncertainty (u), student quality (θ), motivation to learn and interest in the class (λ), and employment hours (h). That is, $P_E = P_E\left(\bar{q}, \bar{u}, \bar{\theta}, \bar{\lambda}, \overset{+}{h}\right)$.

3.3. The Price Function of Out-of-Class Effort

Similarly, there also is an opportunity cost of devoting effort outside the classroom, which is the price of studying outside the classroom (i.e., the price of out-of-class effort, denoted by P_S). The price of out-of-class effort can be impacted by a student's employment hours (denoted by h). The greater the number of work hours, the higher the opportunity cost of devoting effort outside the classroom $(i.e., \frac{dP_S}{dh} > 0)$. For instance, a student (say Student A) who has a 40-hour/week job may have less time than a student (say Student B) who has a 20-hour/week job to study for the course. Assuming that these two students are of the same quality and if we can quantify the knowledge, Student A may produce fewer units of knowledge than Student B does. In order to produce the same units of knowledge as Student B does, Student A will need to reduce some of his/her leisure time (e.g., sleeping time), which raises the cost.

In addition, the price of out-of-class effort is affected by a student's quality. The higher the student's quality, the lower the opportunity cost of devoting effort outside the classroom $(i.e., \frac{dP_S}{d\theta} < 0)$. A higher-quality student usually grasps the content of the textbook, lecture notes, and other references more quickly than a lower-quality student. The example and explanation can be referred to the impact of a student's quality on the price of attending class in Section 3.2. As a result, the lower-quality student has the higher opportunity cost of devoting effort outside the classroom than the higher-quality student does.

Moreover, the price of out-of-class effort can be influenced by a student's motivation to learn and interest in the class (denoted by λ). The greater the student's motivation to learn and be interested in the class, the lower the opportunity cost of studying for the class $(i.e., \frac{dP_S}{d\lambda} < 0)$. The example can be referred to as the impact of a student's motivation to learn and interest in the class on the price of attending class (see section 3.2). The more motivated student will always concentrate on studying; while the less motivated student may be frequently distracted during studying (e.g., checking the Internet or texting while studying). Consequently, the opportunity cost of devoting effort outside the classroom is relatively lower for the highly motivated student than for the one lacking interest in the class who is less motivated to study the course material.

In short, the price of out-of-class effort is a function of employment hours (*h*), student quality (θ), and motivation to learn and interest in the class (λ). That is, $P_S = P_S\left(\overset{+}{h}, \overset{-}{\theta}, \overset{-}{\lambda}\right)$.

3.4 Iso-Cost Line

Furthermore, every student has maximum ability[5] that can be brought to bear on learning opportunity cost (denoted by Ψ). A student's maximum ability (Ψ) is affected by his/her quality. Thus, the higher the student's quality, the higher his/her available maximum ability to take on the learning opportunity cost $(i.e., \frac{d\Psi}{d\theta} > 0)$. A higher-quality student normally grasps lectures in class, the content of the textbook, lecture notes, and other references more quickly than a lower-quality student, implying that the higher-quality student is more productive in constructing knowledge than the lower-quality student.

In addition, a student's maximum ability is influenced by his/her interest in the class and motivation to learn. The greater a student's motivation to learn and interest in the class, the greater will be that student's ability to make maximum effort toward the learning opportunity cost $(i.e., \frac{d\Psi}{d\lambda} > 0)$. The explanation is as offered in the reason illustrated above.

Moreover, a student's maximum ability can be influenced by his/her work hours for pay. The greater the number of work hours for pay, the lower will be the student's maximum ability toward the learning opportunity cost $(i.e., \frac{d\Psi}{dh} < 0)$. For example, a student (Student A) who works at a job forty hours a week will have less time than a student (Student B) who works twenty hours a week to study for the course. Thus, Student A will have lower maximum ability for the learning opportunity cost than Student B.

Above all, maximum ability is a function of student quality (θ), motivation to learn and interest in the class (λ), and employment hours (h). That is, $\Psi = \Psi\left(\overset{+}{\theta}, \overset{+}{\lambda}, \overset{-}{h}\right)$. Furthermore, the student's available maximum ability (Ψ) should be equal to his/her maximum affordable learning opportunity cost (denoted by C). A student's maximum ability that can be brought to bear on the learning opportunity cost to produce the knowledge can be regarded as a producer's maximum asset that can exert an impact on the production cost of developing a product. Thus, the higher the producer's asset, the higher the production cost that is affordable to the producer. For example, if the producer's maximum asset is \$1,000,000, then the producer's maximum production cost must be equal to \$1,000,000.

Similarly, if a student works 60 hours a week for pay, then the student's opportunity cost of being a full-time student in school must be very high. If the student cannot afford this opportunity cost, the student would either withdraw from the school or be a part-time student (e.g., taking one class). This implies that the maximum ability for the student to continue the class should be equal to the maximum affordable learning opportunity cost (C) for the student. Hence, $\Psi = C = C\left(\overset{+}{\theta}, \overset{+}{\lambda}, \overset{-}{h}\right)$. Thus, the student's iso-cost line[6] can be expressed as: $P_E(q,u,\theta,\lambda,h) \cdot E + P_S(h,\theta) \cdot S = C(\theta,\lambda,h)$.

3.5 Equilibrium

Choosing E and S can solve the student's optimization problem, which maximizes $G = G(E,S;I)$ subject to $P_E(q,u,\theta,\lambda)\cdot E + P_S(h,\theta)\cdot S = C(\theta,\lambda,h)$. The Lagrangian expression is set up as follows:

$$L = G(E,S;I) + \delta\,[C(\theta,\lambda,h) - P_E(q,u,\theta,\lambda)\cdot E - P_S(h,\theta)\cdot S],$$

where δ stands for the Lagrangian multiplier or a shadow price. Meanwhile, the Lagrangian expression yields the following first-order conditions for the constrained maximum:

$$\frac{G_E}{P_E} = \frac{G_S}{P_S} \tag{1}$$

$$C = P_E E + P_S S \tag{2}$$

According to Equations (1) and (2), we can solve the equilibriums of these two efforts:

$E^*\left(P_E(q,u,\theta,\lambda,h), P_S(h,\theta,\lambda), C(\theta,\lambda,h)\right) = E^*\left(q,u,\theta,\lambda,h\right)$ and $S^*\left(P_E(q,u,\theta,\lambda,h), P_S(h,\theta,\lambda), C(\theta,\lambda,h)\right) = S^*\left(q,u,\theta,\lambda,h\right)$.

We then aubatitute $E^*(q,u,\theta,\lambda,h)$ and $S^*(q,u,\theta,\lambda,h)$ into the grade function (G), which can be solved as:

$$G^*\left(P_E(q,u,\theta,\lambda,h), P_S(h,\theta,\lambda), C(\theta,\lambda,h); I\right) = G^*\left(q,u,\theta,\lambda,h; I\right).$$

IV. Comparative Static Analysis and Specification

In this section, we offer the comparative static analysis. First, we further totally differentiate Equations (1) and (2) and obtain:

$$\begin{bmatrix} G_{EE}P_S - G_{SE}P_E & G_{ES}P_S - G_{SS}P_E \\ -P_E & -P_S \end{bmatrix} \begin{bmatrix} dE \\ dS \end{bmatrix} = \begin{bmatrix} G_S & -G_E & 0 \\ E & S & -1 \end{bmatrix} \begin{bmatrix} dP_E \\ dP_S \\ dC \end{bmatrix}$$

Let $|D|$ be the determinant of the pre-multiplied matrix of vector [dE dS], which can be shown to be positive. Second, using Cramer's rule, the straightforward comparative static analysis yields:

$$\frac{dE}{dP_E} = \frac{\begin{vmatrix} G_S & G_{ES}P_S - G_{SS}P_E \\ E & -P_S \end{vmatrix}}{|D|} < 0 \tag{3}$$

$$\frac{dE}{dP_S} = \frac{\begin{vmatrix} G_E & G_{ES}P_S - G_{SS}P_E \\ S & -P_S \end{vmatrix}}{|D|} >= or < 0 \tag{4}$$

$$\frac{dE}{dC} = \frac{\begin{vmatrix} 0 & G_{ES}P_S - G_{SS}P_E \\ -1 & -P_S \end{vmatrix}}{|D|} > 0 \tag{5}$$

$$\frac{dS}{dP_E} = \frac{\begin{vmatrix} G_{EE}P_S - G_{SE}P_E & G_S \\ -P_E & E \end{vmatrix}}{|D|} >= or < 0 \tag{6}$$

$$\frac{dS}{dP_S} = \frac{\begin{vmatrix} G_{EE}P_S - G_{SE}P_E & -G_E \\ -P_E & S \end{vmatrix}}{|D|} < 0 \tag{7}$$

$$\frac{dS}{dC} = \frac{\begin{vmatrix} G_{EE}P_S - G_{SE}P_E & 0 \\ -P_E & -1 \end{vmatrix}}{|D|} > 0 \tag{8}$$

Intuitively, as Equations (3) and (6) show, a rise in the price of in-class effort discourages a student's demand for in-class effort investment, but does not provide consistent information about out-of-class effort investment. Similarly, as Equations (4) and (7) show, an increase in the price of out-of-class effort lowers demand for out-of-class effort investment and uncertainty about in-class effort investment. Finally, as Equations (5) and (8) show, a student's maximum affordable learning opportunity cost enhancement increases demands for both in-class and out-of-class effort investment.

We now connect the comparative static analysis shown above with the price functions of in-class and out-of-class efforts (*i.e.*, $P_E = P_E\left(\overset{-}{q}, \overset{-}{u}, \overset{-}{\theta}, \overset{-}{\lambda}, \overset{+}{h}\right)$ and $P_S = P_S\left(\overset{+}{h}, \overset{-}{\theta}, \overset{-}{\lambda}\right)$). The summary is shown below:

1. $\dfrac{dP_E}{dq} < 0 \text{ and } \dfrac{dE}{dP_E} < 0 \Rightarrow \dfrac{dE}{dq} > 0$

2. $\dfrac{dP_E}{du} < 0 \text{ and } \dfrac{dE}{dP_E} < 0 \Rightarrow \dfrac{dE}{du} > 0$

3. $\dfrac{dP_E}{d\theta} < 0 \text{ and } \dfrac{dE}{dP_E} < 0 \Rightarrow \dfrac{dE}{d\theta} > 0$

4. $\dfrac{dP_E}{d\lambda} < 0 \text{ and } \dfrac{dE}{dP_E} < 0 \Rightarrow \dfrac{dE}{d\lambda} > 0$

5. $\dfrac{dP_E}{dh} > 0 \text{ and } \dfrac{dE}{dP_E} < 0 \Rightarrow \dfrac{dE}{dh} < 0$

6. $\dfrac{dP_S}{dh} > 0 \text{ and } \dfrac{dS}{dP_S} < 0 \Rightarrow \dfrac{dS}{dh} < 0$

7. $\frac{dP_S}{d\theta} < 0 \text{ and } \frac{dS}{dP_S} < 0 \Rightarrow \frac{dS}{d\theta} > 0$

8. $\frac{dP_S}{d\lambda} < 0 \text{ and } \frac{dS}{dP_S} < 0 \Rightarrow \frac{dS}{d\lambda} > 0$

Based upon the theoretical framework, each student will choose his or her optimal combination of in-class and out-of-class efforts (E^* and S^*) to maximize his or her grade at the G^* level (see Figure 1).

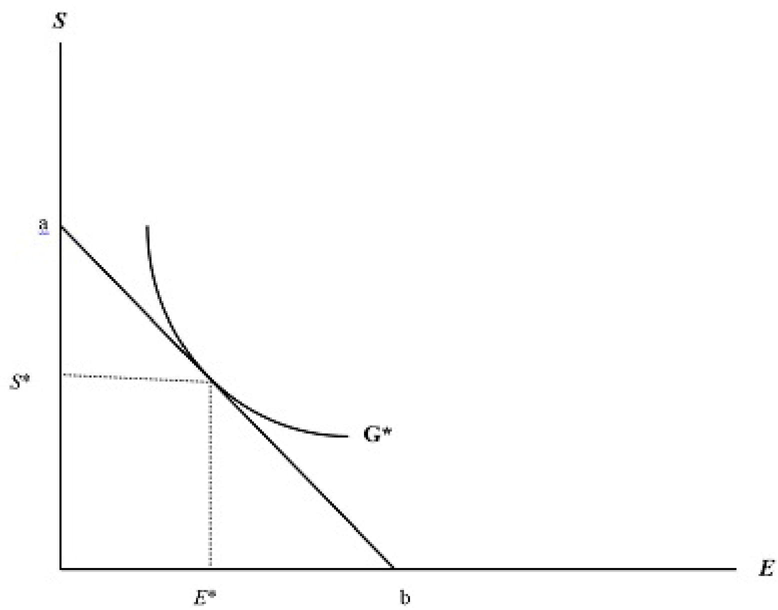

Figure 1. Students' Optimal In-class and Out-of-class Efforts

Therefore, both of these two equilibrium efforts (E^* and S^*) are related to percentage of course grade for quizzes (q), uncertainty (u), student's quality (θ), student's interest in the class and motivation to learn (λ), and student's employment hours per week (h); while a student's equilibrium grade (G^*) is related to percentage of course grade for quizzes (q), uncertainty (u), student's quality (θ), student's interest in the class and motivation to learn (λ), student's employment hours per week (h), and instructor's instructional skills/school environment (I). That is:

$$E^*\left(\overset{-}{P}_E\left(\overset{-}{q},\overset{-}{u},\overset{-}{\theta},\overset{-}{\lambda},\overset{+}{h}\right),\overset{?\,-}{P_S}\left(\overset{+}{h},\overset{-}{\theta},\overset{-}{\lambda}\right),\overset{+}{C}\left(\overset{+}{\theta},\overset{+}{\lambda}\overset{-}{h}\right)\right)=E^*\left(\overset{+}{q},\overset{+}{u},\overset{+}{\theta},\overset{+}{\lambda},\overset{-}{h}\right),$$

$$S^*\left(\overset{?}{P}_E\left(\overset{-}{q},\overset{-}{u},\overset{-}{\theta},\overset{-}{\lambda},\overset{+}{h}\right),\overset{-}{P}_S\left(\overset{+}{h},\overset{-}{\theta},\overset{-}{\lambda}\right),\overset{+}{C}\left(\overset{+}{\theta},\overset{+}{\lambda}\overset{-}{h}\right)\right)=S^*\left(\overset{?}{q},\overset{?}{u},\overset{+}{\theta},\overset{+}{\lambda},\overset{-}{h}\right),\text{and}$$

$$G^*\left(\overset{-}{P}_E\left(\overset{-}{q},\overset{-}{u},\overset{-}{\theta},\overset{-}{\lambda},\overset{+}{h}\right),\overset{-}{P}_S\left(\overset{+}{h},\overset{-}{\theta},\overset{-}{\lambda}\right),\overset{+}{C}\left(\overset{+}{\theta},\overset{+}{\lambda}\overset{-}{h}\right);\overset{+}{I}\right)=G^*\left(\overset{+}{q},\overset{+}{u},\overset{+}{\theta},\overset{+}{\lambda},\overset{-}{h};\overset{+}{I}\right).$$

The purpose of this study was to link quizzes, effort investment, and learning outcomes; thus, we focus our explanation on these relationships: $\frac{dE^*}{dq}>0$, $\frac{dE^*}{du}>0$, $\frac{dS^*}{dq}>=or<0$, $\frac{dS^*}{du}>=or<0$, $\frac{dG^*}{dq}>0$, and $\frac{dG^*}{du}>0$. As shown above, the effects of quizzes (q) and uncertainty (u) on out-of-class effort are ambiguous, implying that there are three different possible cases. To explain these uncertain relationships, we rely on the analysis of the substitution and income effects.

In this paper, the substitution effect means that when the price of in-class effort decreases, the price of out-of-class effort becomes relatively more expensive. Given the same grade, the student is willing to substitute greater employment of in-class effort for out-of-class effort. Therefore, the student will employ more units of in-class effort and fewer units of out-of-class effort. On the other hand, the income effect means that when the price of in-class effort decreases, the student's real maximum ability that can be brought to bear on learning opportunity cost will increase. Hence, the student will employ more units of both in-class and out-of-class efforts. Consequently, in-class effort must increase while out-class-effort is uncertain depending on which effect is dominant. If the income effect outweighs the substitution effect, then out-of-class effort will increase; if the substitution effect exceeds the income effect, then out-of-class effort will decrease; and if these two effects are equal, then out-of-class effort will remain the same. Below, we summarize these results in Table 1:

TABLE 1–Substitution, Income and Total Effects

When $P_E \downarrow$	Substitution Effect (S.E.)	Income Effect (I.E.)	Total Effect (Price Effect)
In-Class Effort (E)	↑	↑	↑
Out-of-Class Effort (S)	↓	↑	If S.E. < I.E. ⇒↑ If S.E. = I.E. ⇒ $\bar{S}$ If S.E. > I.E. ⇒ ↓

When quizzes (either announced or unannounced) are given to students by the professor, as explained earlier, the price of attending class will decrease (i.e., $P_E \downarrow$, that is, the opportunity cost of missing class increases); thus, the student's iso-cost line will shift from *ab* to *ac* (as shown in Figures 2–4). Therefore, there are three possible cases:

(1) Substitution effect < *income effect*: $\frac{dE^*}{dq} > 0, \frac{dE^*}{du} > 0; \frac{dS^*}{dq} > 0, \frac{dS^*}{du} > 0;$ and $\frac{dG^*}{dq} > 0, \frac{dG^*}{du} > 0.$

As Figure 2 shows, due to the substitution effect, the student's out-of-class effort decreases from $S1^*$ to $S2$, while the in-class effort increases from $E1^*$ to $E2$. On the other hand, due to the income effect, the student's out-of-class effort increases from $S2$ to $S2^*$, while the in-class effort increases from $E2$ to $E2^*$. In-class effort must increase, but out-of-class effort is uncertain. Since the substitution effect is less than the income effect, the out-of-class effort ultimately will increase. Therefore, the student will choose optimal efforts $E2^*$ ($> E1^*$) and $S2^*$ ($> S1^*$). As a result, the student attends class more often and studies harder outside the classroom, and eventually achieves at the $G2$ level ($G2 > G1$) and receives a better grade.

(2) Substitution effect = *income effect*:

$$\frac{dE^*}{dq} > 0, \frac{dE^*}{du} > 0; \frac{dS^*}{dq} = 0, \frac{dS^*}{du} = 0; \text{ and } \frac{dG^*}{dq} > 0, \frac{dG^*}{du} > 0.$$

As shown in Figure 3, due to the substitution effect, the student's out-of-class effort drops from S1* to S2, while the in-class effort rises from *E*1* to *E*2. However, because of the income effect, the student's out-of-class effort rises from *S*2 to *S*3*, while the in-class effort rises from *E*2 to *E*3*. In-class effort definitely increases, but out-of-class effort remains uncertain. The substitution effect is now equal to the income effect; hence, the out-of-class effort ultimately does not change. Consequently, the student will choose optimal efforts *E*3* (> *E*2* > *E*1*) and *S*3* (= *S*1* < *S*2*). As a result, the student attends class more frequently but studies outside the classroom as hard as before when quizzes were not given. However, the student eventually still achieves at a higher level, say the *G*3 level (*G*3 > *G*1), and receives a better grade.

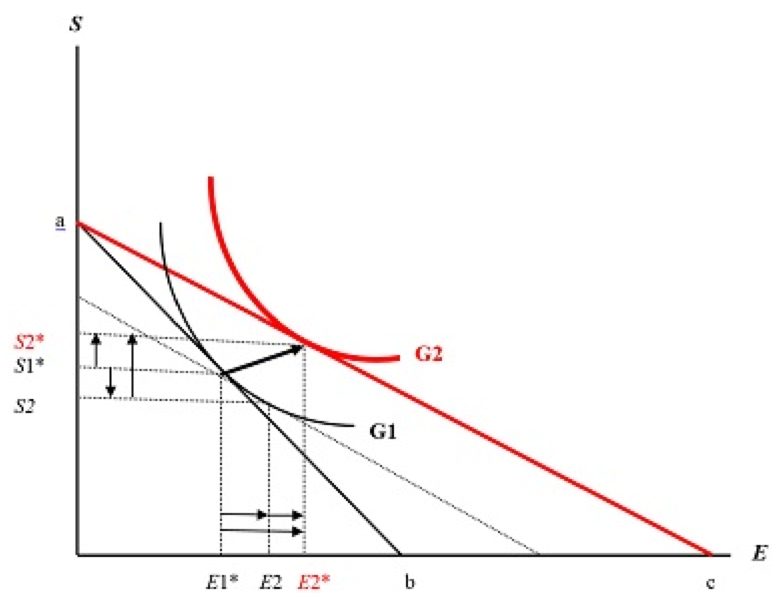

Figure 2. Students' New Optimal In-class and Out-of-class Efforts When Faced with Quizzes: Income Effect Dominates Substitution Effect

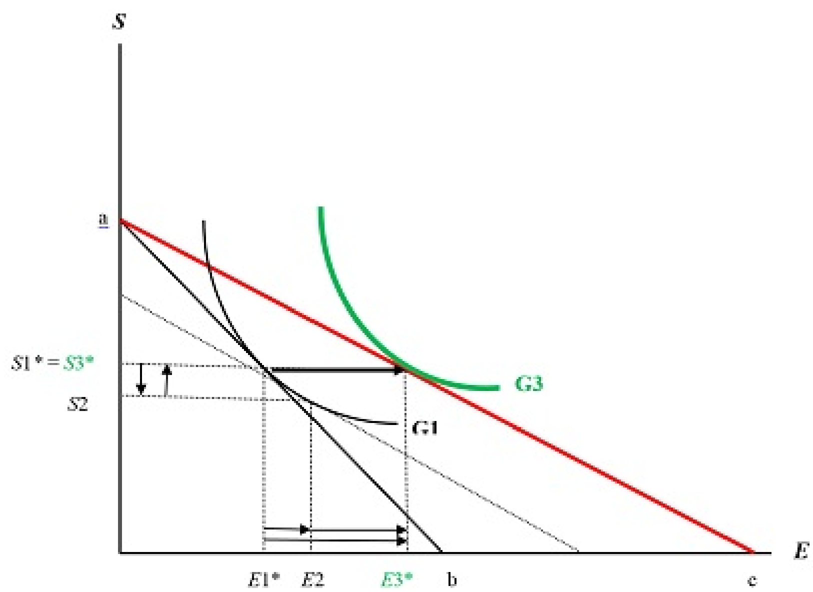

Figure 3. Students' New Optimal In-class and Out-of-class Efforts When Faced with Quizzes: Substitution Effect Equals Income Effect

(3) Substitution effect > *income effect*: $\frac{dE^*}{dq} > 0, \frac{dE^*}{du} > 0; \frac{dS^*}{dq} < 0, \frac{dS^*}{du} < 0$; and $\frac{dG^*}{dq} > 0, \frac{dG^*}{du} > 0$. As Figure 4 shows, due to the substitution effect, the student's out-of-class effort reduces from $S1^*$ to $S2$, while the in-class effort is enhanced from $E1^*$ to $E2$. Due to the income effect, the student's out-of-class effort improves from $S2$ to $S4^*$, while the in-class effort improves from $E2$ to $E4^*$. In-class effort must improve, but out-of-class effort is not certain. Since the substitution effect dominates the income effect, the out-of-class effort ultimately will decrease. For that reason, the student will choose optimal efforts $E4^*$ ($> E3^* > E2^* > E1^*$) and $S4^*$ ($< S1^* = S3^* < S2^*$). Accordingly, while the student attends class much more often, he/she studies slightly less hard outside the classroom. Nevertheless, the student eventually still achieves at a higher level, say the $G4$ level ($G4 > G1$), and receives a better grade.

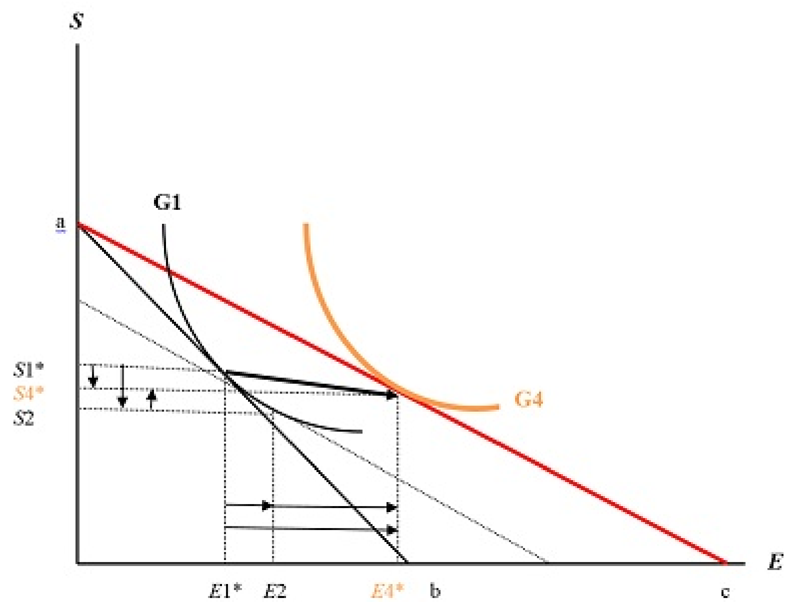

Figure 4. Students' New Optimal In-class and Out-of-class Efforts When Faced with Quizzes: Substitution Effect Dominates Income Effect

In summary, Case 1 would most likely occur in the announced-quiz system; while Cases 2 and 3 would most likely occur in the unannounced-quiz system. This is because students in the announced-quiz system know the schedule of quizzes and the materials covered for quizzes. In order not to lose points from quizzes, students will study ahead of time prior to taking quizzes and attend classes, especially when quizzes are scheduled. However, it is possible that under the announced-quiz system students might not attend class as often. Some students may just attend classes when quizzes and exams are scheduled. On the other hand, students in the unannounced-quiz system do not know the schedule for and materials to be covered on quizzes. For that reason, they might not study ahead of time prior to attending the next class. Nevertheless, due to uncertainty in the unannounced-quiz system, students may choose to attend class more frequently in order to minimize grade loss due to absence. This explains why in-class effort is lower in Case 1 than in Cases 2 and 3, but out-of-class effort is greater in Case 1 than in Cases 2 and 3. This implies that the announced-quiz system would be most likely to increase students' out-of-class effort relative to the unannounced-quiz system; while the unannounced-quiz system would be most likely to enhance students' in-class effort relative to the announced-quiz system.

V. Discussion

We are left with two more issues that need to be further discussed: (1) would different types of quizzes serve different effective instructional purposes in students' learning? (2) Why are student efforts suboptimal absent a quiz?

5.1. Issue 1

Under the announced-quiz system, there is no uncertainty so there is no risk; while under the unannounced-quiz system, there is uncertainty so there is risk. This implies that uncertainty and risk are positively correlated – the greater the uncertainty, the higher the risk. The degree of uncertainty/risk for a student depends on how much the student cares about his/her course grade (i.e., how much the course grade important to the student). If the student thinks that the course grade is extremely important to him/her, the student will feel the risk for him/her is very high. That is, the more the student cares about his/her grade, the higher the level of risk experienced by the student. In addition, when the student cares more about his/her course grade, the student will be more risk-averse, because the student does not want to lose points due to risk/uncertainty. Therefore, the greater the student's experienced level of risk, the more risk-averse the student will be. As a result, the more risk-averse the student is, the higher the student's level of uncertainty.

Thus, the opportunity cost of missing class for a more risk-averse student is higher than the opportunity cost of missing class for a less risk-averse student under the unannounced-quiz system. This is because the uncertainty for the more risk-averse student is higher than for the less risk-averse student. For that reason, given that other factors are unchanged, the price of attending class (i.e., the price of in-class effort) is lower for the more risk-averse student than for the less risk-averse student. Hence, the more risk-averse student will demand more efforts than will the less risk-averse student. That is, the more risk-averse student will attend class more frequently and preview class more regularly than will the less risk-averse student. As a result, the more risk-averse student will likely receive a better grade than the less risk-averse student.

We now compare announced-quiz with unannounced-quiz for more/less risk-averse students. Suppose that a student (say, Student A) is more risk-averse. Under the announced-quiz system, there is no uncertainty/risk; under the unannounced-quiz system, there is uncertainty/risk. Since Student A is more risk-averse, the opportunity cost of missing class for Student A will be a little higher in the unannounced-quiz system than in the announced-quiz system. That is, given that other factors are unchanged, the price of attending class will be a little lower in the unannounced-quiz system than in the announced-quiz system. This is because a more risk-averse student cares more about his/her course grade, implying that uncertainty/risk will lead Student A to choose a more conservative way to invest his/her efforts (such as attending class more frequently and increasing textbook reading prior to class). For that reason, as shown in Figure 5, Student A's iso-cost line will be *ah*, indicating that s/he is choosing optimal efforts $E5^*$ and $S5^*$ under the unannounced-quiz system; while the student's iso-cost line will be *ac,* indicating that s/he is choosing optimal efforts $E2^*$ and $S2^*$ under the announced-quiz system. As a result, the student will attend the class more often and study harder outside the classroom in the unannounced-quiz system than in the announced-quiz system, and eventually achieve at the $G5$ level ($G5 > G2$) and receive a better grade in the unannounced-quiz system than in the announced-quiz system.

On the other hand, if a student (say Student B) is less risk-averse, under the unannounced-quiz system the opportunity cost of missing class for Student B may be a little lower than the opportunity cost of missing class for students in the announced-quiz system. That is, given that other factors are unchanged, the price of attending class will be a little higher in the unannounced-quiz system than in the announced-quiz system. This is because a less risk-averse student cares less about his/her course grade, implying that uncertainty/risk will not lead Student B to choose a more conservative way to invest his/her efforts or perhaps to choose a less conservative way to invest his/her efforts (such as attending class less frequently and decreasing textbook reading prior to class). Therefore, as shown in Figure 6, Student B's iso-cost line will be *mn,* indicating that s/he is choosing optimal efforts $E6^*$ and $S6^*$ under the announced-quiz system; while the student's iso-cost line will be *mi,* indicating that s/he is choosing optimal efforts $E7^*$ and $S7^*$ under the unannounced-quiz system.

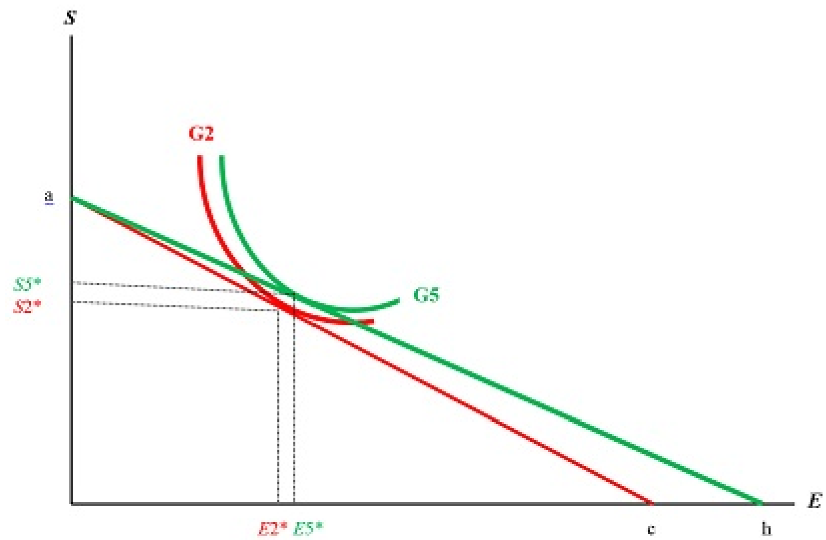

Figure 5.Comparison of Announced-Quiz and Unannounced-Quiz
If the Student is More Risk-Averse

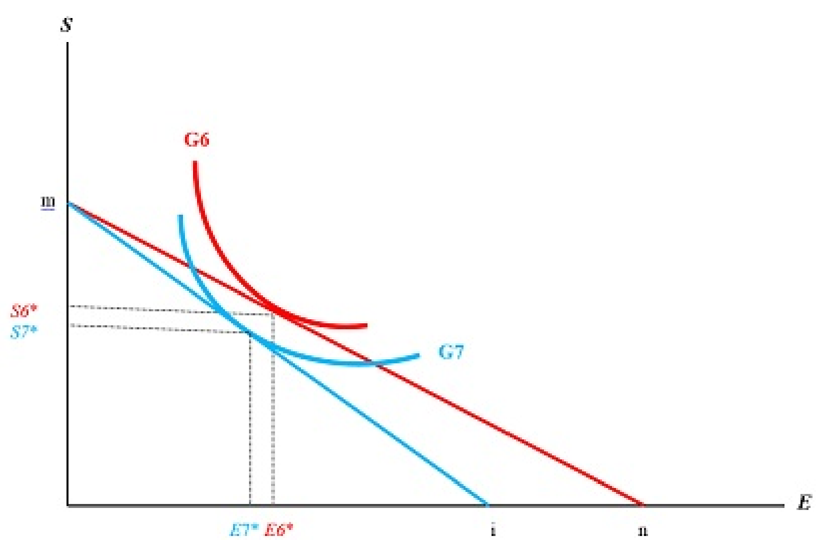

Figure 6. Comparison of Announced-Quiz and Unannounced-Quiz
If the Student is Less Risk-Averse

As a result, the student may attend the class less often and study less hard outside the classroom in the unannounced-quiz system than in the announced-quiz system, and eventually achieve at the $G7$ level ($G7 < G6$) and receive a lower grade in the unannounced-quiz system than in the announced-quiz system.

Based upon the theoretical analysis expressed above, we may conclude that the unannounced-quiz system will serve as a more effective instructional method for more risk-averse students' learning; while the announced-quiz system will serve as a more effective instructional method for less risk-averse students' learning.

We raise one more inquiry: what kind of students would be more risk-averse? We hypothesize that high GPA students are likely to be more risk-averse since they would like to maintain their high GPAs. To determine whether our hypothesis is correct, we will need to conduct an empirical study on this topic in the future.

5.2 Issue 2

The theoretical analysis has demonstrated that quizzes (unannounced-quizzes or announced-quizzes) can promote student effort, especially in-class effort (attendance). However, some could argue that in reality students still skip class and miss scheduled quizzes under the announced-quiz without a makeup quiz policy, implying that quizzes cannot promote student effort, which conflicts with our model. In other words, their argument raises a question: why are student efforts suboptimal absent a quiz? Below, we provide our explanation.

We believe that there are negative externalities (such as employment hours) from knowledge acquisition in the model. Employment hours are believed to be a primary negative externality. According to the model, when a student's employment hours (h) increase, this will raise the opportunity cost of attending class (i.e., the price of in-class effort will increase, $P_E \uparrow$). While quizzes will lower the price of in-class effort, employment hours will raise the price of in-class effort. Therefore, the overall effect will depend on which effect is dominant. We specify three possible cases:

(1) If a student has a significantly large number of employment hours (e.g., 50 or more hours a week – the student works 2 or more jobs), then the increase in the price of in-class effort will outweigh the

decrease in the price of in-class effort. Thus, the price of in-class effort still increases eventually for the student. Consequently, the student will determine his/her suboptimal choice by opting to skip class and miss quizzes in order to keep his/her job(s); otherwise, the student may not be able to afford college.[7] The student may be still a grade maximizer; but under the suboptimal choice, the student's objective function may not be an A or a B grade. Instead, the student may just want to pursue a C or a passing grade (say D). This is because the student does face constraints in the form of an opportunity cost of time.

(2) If the increase in the price of in-class effort for the student due to employment hours is equal to the decrease in the price of in-class effort due to quizzes, then the price of in-class effort eventually will remain the same for the student. As a result, the student's investment in effort may not be influenced by quizzes. The student will not particularly increase/decrease his/her effort investment due to quizzes. That is, the positive effect due to quizzes would be completely offset by the negative effect due to employment hours.

(3) If the decrease in the price of in-class effort for the student due to quizzes exceeds the increase in the price of in-class effort due to employment hours (e.g., the student only works 20 or fewer hours a week), then the price of in-class effort eventually will decrease for the student. Therefore, the student will enhance his/her effort investment. This is because the positive effect due to quizzes dominates the negative effect due to employment hours.

In short, our model indeed does not conflict with the reality that students still skip class and miss quizzes. This is because negative externalities (such as employment hours) from knowledge acquisition exist in the model, which offsets the positive effect on effort investment from quizzes. On the other hand, the positive effect from quizzes may be offset by the negative effect from employment hours; without quizzes, the negative effect could be even bigger. Therefore, quizzes can be an effective instructional tool in promoting student effort when each quiz weights a significant percentage of the course grade, which may enlarge the positive effect and thus enhance the possibility of dominating the negative effect of negative externalities, such as employment hours.

VI. Conclusion

In this paper, using the theory of producer choice, a basic economic theoretical model was constructed to illustrate how quizzes (unannounced-quizzes or announced-quizzes) can affect a student's behavior in effort-investment and learning performance. The theoretical model mainly focuses on an economic perspective to explain the economic relationships between quizzes and education output (i.e., exam performance), in-class effort (i.e., attendance), and out-of-class effort.

In light of the theoretical results, five findings are offered:

1. When quizzes (unannounced-quiz or announced-quiz) are given to students before they take exams, students will perform better on exams.
2. Facing the possibility of quizzes (unannounced-quiz or announced-quiz), students will increase their in-class effort investment in order to minimize their grade loss from being absent, but not certainty about their out-of-class effort investment.
3. The unannounced-quiz system will most likely increase student in-class effort relative to the announced-quiz system; the announced-quiz system will most likely enhance student out-of-class effort relative to the unannounced-quiz system.
4. The unannounced-quiz system will serve as a more effective instructional method for more risk-averse students' learning; while the announced-quiz system will serve as a more effective instructional method for less risk-averse students' learning.
5. When a student has a significantly large number of employment hours, the negative effect from employment hours will likely dominate the positive effect from quizzes, and thus student efforts may be suboptimal absent a quiz.

In summary, the main purpose of this paper is to frame an economic theoretical background for quizzes, which can be useful in constructing empirical models for further investigations of this issue. Our theoretical analysis has demonstrated that quizzes improve student exam performance. Nevertheless, we still need a further empirical study and more data evidence to demonstrate whether quizzes can unambiguously improve students' exam performance in reality. We leave this topic for our future investigation.

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Endnotes

1. Whether students can be regarded as producers or consumers depends on analytical focuses. When students are viewed as consumers, the focus is on the demand side and thus the theory of consumer choice has to be used. On the other hand, when students are viewed as producers, the focus is on the supply side and hence the theory of producer choice has to be used. In this paper, students are regarded as producers because we focus on student knowledge production – students invest their efforts to produce their "*knowledge*", and the quiz is one of the factors that would affect a student's effort-investment decision and hence influences the student's knowledge production. Obviously, we focus on the supply side, so the theory of producer choice rather than the theory of consumer choice has to be used. A theoretical article on students as consumers that uses the theory of consumer choice is Lin (2009). An empirical article whose author demonstrates that students behave like producers is Lin (2013).
2. This is an assumption. In reality, it is possible that some professors may inflate students' grades, and thus the level of knowledge acquired cannot be precisely reflected in students' grades.

3. One may argue that it is possible for a bright student or one who for a variety of reasons may already have considerable knowledge of the material to likely get a good grade even if he/she does not gain much from the class. Our argument is that it does not matter whether or not the knowledge is gained from the class. The point is that the student does have that knowledge so that he/she can get a good grade. The bright student may spend more out-of-class effort to gain that knowledge. Therefore, it is reasonable to assume that grades are based upon the knowledge a student acquires without grade inflation.
4. It is necessary to assume that unannounced quizzes can be given without allowing make-ups under any circumstances. Without this assumption, the unannounced quizzes would become "announced quizzes" for absent students who are allowed to take make-ups, and thus the factor of "uncertainty" will not exist in the model.
5. "Maximum ability" refers to a student's ability to afford the maximum opportunity cost of learning the course in order to continue the class.
6. In the theory of producer choice, the iso-cost line is a line that shows the various combinations of labor and capital that the producer can hire or rent for the given total cost. In this paper, the iso-cost line shows the various combinations of in-class effort and out-of-class effort that the student can use for the given maximum affordable learning opportunity cost.
7. Surveys from King and Bannon (2002) and Lin (2014) demonstrated that the majority of college students would not be able to afford college if they did not work.

The Effects of Academic and Athletic Quality on Undergraduate Admissions

Robert Quinn and Jamie Price Pelley*

ABSTRACT. A great many factors influence students' choices regarding which college to attend, including social concerns, financial issues, academic reputation, and sports environment. In order to examine how the demand for education varies by economic conditions, a cross-section of colleges and universities was examined by looking at a basic demand function that included consumption factors, such as Power Five conference membership, in both a "typical" year and a year at the end of the Great Recession. The data used for the current study was the College and Universities 2000 Project (Brint, Mulligan, Rotondi, & Apkarian, 2011) that included data from select years through 2010. The authors used a model including two years of cross-sectional data to test overall demand, demand for private and public colleges and universities, and demand for very high research and lower research institutions. Quality, using a Barron's rating as a proxy, was an important influence on demand in all models. Membership in a Power Five athletic conference was also an important influence. Overall, the results did indicate that consumption factors were important inputs in the demand for colleges and universities, regardless of the overall condition of the economy. (I21)

I. Introduction

According to the New York Times, the Bureau of Labor Statistics reported that in October 2013, "65.9 percent of people who had graduated from high school that previous spring had enrolled in college" (N.Y. Times, 2014). Although down 4.2% from a high of 70.1 percent reported in 2009, that figure indicated that nearly two-thirds of U.S. high school graduates still elect to attend some sort of college. A great many factors influence students' choices regarding which college to attend, most notably social concerns, financial issues, academic reputation, and sports environment. The current paper examined how the demand for a college education, as approximated by the number of applicants, is partially determined by consumption factors such as the perceived quality of the school in both academics and athletics.

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For many students the college decision is a financial one, leading them to select the public college closest to their homes (either two-year or four-year depending upon their interests). Others select the closest college because of marked preferences for remaining close to family and friends. In either case, this is often referred to as going to "thirteenth grade", as the student's experience is frequently rather similar to their high school experience (at least socially). Whether for financial or personal reasons, this group is not so much selecting a college, but is selecting whether or not to attend college and hence would be a part of the constant term in this study.

In this paper, we are more interested in observing the group who have chosen definitively to attend college and are conducting a broader search for the "perfect" college. Two factors of particular interest are the academic reputation of the school and the sports environment of the institution. Collectively, academic reputation and sports environment represent consumption factors, while tuition and other associated costs are investment factors in the decision to attend a certain college. One consumption variable is that of academic reputation. One way of measuring reputation is by its admissions selectivity, as measured by Barron's Profile of American Colleges (Barron's Educational Services, 2013). In the Barron's guide a "one" is given to the most selective admissions process, while a "six" is given to the least or non-competitive admissions process. The more competitive schools are perhaps more attractive from both a consumption standpoint (i.e. the prestige of membership in an elite group) and an investment standpoint (i.e. a better network which could lead to a better job or graduate school placement). As noted, the sports environment is another important consumption variable. McCormick and Tinsley (1987) demonstrated a positive correlation between SAT scores and the number of applications to a given college after a particularly successful sports season. McCormick and Tinsley refer to this as an advertising effect in that potential applicants hear publicity about a college and its success in athletics and this type of advertising leads them to want to apply to that institution. The authors saw a symbiotic relationship between athletics and academics. Membership in one of the "Power Five" athletic conferences is one measurement of the sports atmosphere of a given institution. The Power Five conferences include the Atlantic Coast Conference (ACC), the Big Ten Conference, the Big XII Conference, the Pacific 12 Conference, and the Southeastern Conference.

For this study, we wished to determine whether these consumption factors' influence on the desirability of institutions varied according to the state of the economy. We were particularly interested in the impact of the Great Recession of 2008 to 2009 on these consumption factors. A dummy variable representing the year was included in the regression to see if demand changed between a year before the Great Recession and a year at the very end of it. In order to examine how the demand for education varied by economic conditions, we examined a two year sample of colleges and universities using a basic demand function that included consumption factors, such as Power Five conference membership, in both a "normal' year, economically speaking, and a year during the Great Recession. The results of the models show that consumption factors, specifically quality and athletics, are indeed important determinants of the demand for college as measured by the number of applicants.

II. Literature Review

Many studies on the demand for higher education have focused on postsecondary education as a consumption good. Some authors who included consumption variables in their demand for education functions were Gullason (1989), Lehr and Newton (1978), Quinn and Price (1998), and Quinn and Pelley (2013). In his study of the demand for postsecondary education, Gullason (1989) found that enrollment at a postsecondary institution could be used as a means of avoiding the draft during the Korean and Vietnam Wars. Similarly, Lehr and Newton (1978) examined the demand for higher education as a type of individual choice behavior. Quinn and Price (1998) added consumption variables to a basic human capital model with mixed, but overall weak, results for the significance of the consumption variables, while Quinn and Pelley (2013) found some evidence for the political environment as represented by the party of the President of the United States as an influence on the demand for law school, with the number of LSATs administered tending to be higher in years when a Republican was President of the United States.

Pissarides (2011) wrote that the demand for education, especially the demand for private education is known to rise during recessions. Similarly, Walstrum (2014) discussed local labor market shocks and showed that the demand for higher education does rise when the opportunity cost of higher education falls (as measured by a higher unemployment rate). Kim (2014) also found the demand for higher education to be countercyclical, but subject to supply constraints and found that high prestige schools can respond to worsening economic conditions by becoming choosier in order to increase the quality of incoming students.

Numerous researchers have used cross sectional data, as well as longitudinal and panel data, to analyze the demand for education at colleges and universities. Jacob, McCall, and Strange (2011) use cross sectional data to examine undergraduate college choice and found that consumption attributes such as sports, activities, and academic quality were important determinants of demand. Fuller, Manski, and Wise (1982) used a multinomial logit model to look at the revealed preferences among the available schooling and work alternatives, and found the availability of financial aid to be an important determinant of demand. Hemelt and Marcotte (2011) examined the impact of rising tuition rates on enrollment at four-year public colleges and universities. They found no evidence, even with increases in real tuition that the price elasticity of the demand for public education had increased. Doyle and Cicarelli (1980) estimated the demand for education using a cross section of 40 public four-year institutions, with enrollment as the dependent variable. The authors also included a quality term, the ranking according to *Barron's Profiles of American Colleges*, and concluded that public education was an inferior good. Additionally, they found that price and quality, even though having the correct sign, were not significantly different from zero.

Other studies introduced the element of collegiate athletics, specifically the influences of big-time college football and basketball, success in these sports, conference membership, and football culture as determinants of the demand for postsecondary education. Smith (2009) directly examined football success as a determinant of the demand for a college and university education. Using random effects GLS models, he found football culture and tradition as measured by the number of years playing football to be the most important determinant of demand. Toma and Cross (1998) analyzed the effect of winning a national championship in football or men's basketball on the quantity of undergraduate applications received by institutions competing in Division I of the National Collegiate Athletics Association (NCAA). Their preliminary findings suggested that success in intercollegiate athletics translated into an increase in the number of applications received both in absolute terms and relative to peer institutions.

Similarly, Pope and Pope (2009) estimated a demand function for college education that included the success of the institution's football and basketball teams in the equation. The authors did use the number of applicants as a measure of demand. Regressions of approximately 330 Division I institutions were run separately for both public schools and private schools. The authors found that football and basketball success did increase the quantity of applications to institutions. They further suggested that the extra applications were used to increase both student quality and enrollment size.

III. Brief Look at the Data

The data used for the current study was the College and Universities 2000 Project (Brint, Mulligan, Rotondi, and Apkarian, 2011) which included data from select years through 2010. We used data from 2005 and 2010. This allowed us to compare a year at the end of the Great Recession with a slightly earlier, pre-recession year. Although the Great Recession ended in June, 2009 (NBER, 2016), the recovery was slow and potential students would still be affected by the recession in preparing for the 2009-2010 academic year. The survey included 382 colleges and universities in the U.S., with 209 private and 173 public institutions. Of these institutions, 130 were baccalaureate institutions, 126 were Master's institutions, 55 were doctoral or research universities, and 71 were research universities with very high research activity, according to their Carnegie classification. Forty of these institutions were members of one of the so-called Power Five football conferences: the Big 10, Big 12, Atlantic Coast Conference, Southeastern Conference, or the Pacific 12. The colleges and universities were from geographically diverse regions. The geographic dispersion by census region is shown in Figure 1.

The available data for this sample goes back to 1970, and most data was available in five years intervals through 2010. For this project data from 2005 and 2010 were analyzed. A major variable of interest, total entering students at the undergraduate level, was only available in these years. The total number of applicants each year was not available as a separate variable in the data set. The percentage of undergraduate applicants admitted, however, was available. A proxy for applicants was therefore calculated by dividing the total entering students at the undergraduate level by the percentage of undergraduates admitted.

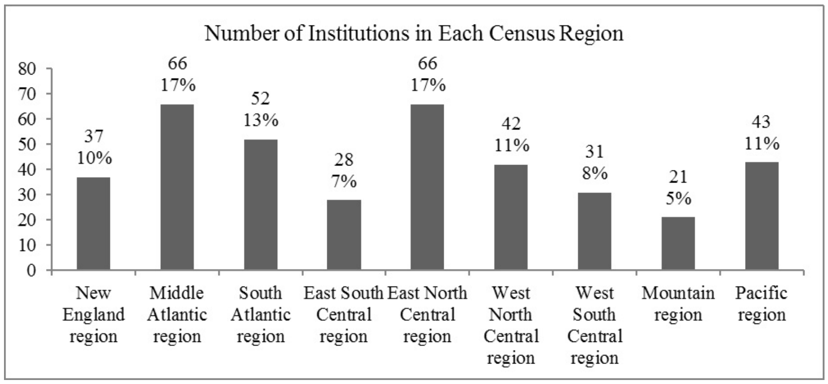

Figure 1. Number of four year colleges and universities included in the sample, by census region.

This should be a close measure of total undergraduate applicants, as the number of entering students would be expected to be close to the number of accepted students. The mean values of undergraduate enrollment, percentage of undergraduate applicants admitted, and the calculated dependent variable, undergraduate applicants, are shown in Tables 1 and 2.

TABLE 1–Mean Undergraduate Applicants and Enrollment, 2005

	Number of Schools	Mean First Time Enrollment	Mean Percent of Undergraduates Admitted	Mean Undergraduate Applicants
All colleges and universities	376	2001.26	65.82%	3630.98
Private colleges and universities	200	850.18	61.16%	2104.33
Public colleges and universities	163	3411.16	71.32%	5504.18
Public colleges and universities excluding very high research universities	175	692.77	65.74%	1187.23
Private colleges and universities excluding very high research universities	120	2416.63	74.08%	3608.50

TABLE 2–Mean Undergraduate Applicants and Enrollment, 2010

	Number of Schools	Mean First Time Enrollment	Mean Percent of Undergraduates Admitted	Mean Undergraduate Applicants
All colleges and universities	367	2246.20	61.36%	4499.77
Private colleges and universities	200	1000.82	56.29%	2975.44
Public colleges and universities	167	3761.05	67.40%	6325.33
Public colleges and universities excluding very high research universities	172	829.56	61.67%	1443.10
Private colleges and universities excluding very high research universities	125	2731.95	70.58%	4095.07

Most demand studies examine enrollment figures. In theory, enrollments at colleges and universities will be at an equilibrium level where supply = demand. Enrollment demand is negatively related to tuition while enrollment supply is positively related (Fortin, 2004). For the current study, we used using applicant data rather than enrollment data in order to reflect the number of potential students interested in attending a particular school as the dependent variable measuring the demand for education (Savoca, 1990; Pope & Pope, 2009; Quinn & Price, 1996). Doyle and Cicarelli (1980) discussed that "predicting enrollment for a given college is analogous to forecasting demand for an individual firm" (p. 53). Applicant numbers can potentially yield an even clearer picture of demand because they are unaffected by supply. Bound, Hershbein, and Long (2009) discussed how the supply of college admission slots did not keep pace with demand and therefore enrollments increased slower than the actual demand for education. While the supply function of education is likely to affect enrollments, the number of applicants should be a pure demand phenomenon.

IV. The Models

To analyze the data, we treated the data as a type of panel study with very a large number of cross sections while each unit was observed only twice (Beck, 2004; Hsiao, 2014). According to Hsiao (2014), analyzing the data as a panel instead of two separate cross-sectional models increases the degrees of freedom, reduces collinearity among explanatory variables, and allows more research questions to be analyzed. Although the sample includes only two years of data, it is still is version of a panel model. Because only two years were used in the study, serial correlation would not be a problem. Heteroscedasticity, however, was a potential problem in the data because of the large cross-sectional component (Hecock, 2003). Therefore, because of this potential problem, all models were tested for heteroscedasticity.

The demand function used in the research was a basic demand function of the form:

(1) Demand = f (Price, Availability of financial aid, Price of substitute good (if applicable), Academic quality, Athletic quality, Year)

The functional form of the model for all colleges and universities was:

(2) $\ln(\text{applicants}_{i,t}) = a + b_1\ln(\text{Tuition}_{i,t}) + b_2\ln(\text{Change in financial aid}_{i,t}) + b_3\ln(\text{Barrons}_{i,t}) + b_4\,\text{High research}_{i,t} + b_5\,\text{Power 5}_{i,t} + b_6\text{Year}_{i,t} + u_{i,t}$

where i=1, . . . , N, or is the cross-sectional component, t is the time series component of 2005 or 2010, and u is the error term. The variables included in this demand function are explained in Table 3.

The demand function we employed in the study was based loosely on the demand functions of Doyle and Cicarelli (1980), Pope and Pope (2009), and Hemelt and Marcotte (2011). The demand function is also similar to that of Bezmen & Depken (1998) who also used the number of applicants to a given school as their measure of demand. Past research also influenced our choice of independent variables. Price (tuition) is an important element of any demand function, including the demand for education. Studies have closely examined the price elasticities of the demand for postsecondary education (Leslie & Brinkman, 1987; Heller, 1997). Although some studies have hypothesized that tuition is not a fully exogenous variable because "the supply of enrollment places is not fully elastic" (Allen & Shen, 1999, p. 466), many demand studies do treat tuition as a fully independent variable (Bezmen & Depken, 1998; Curs & Singell Jr., 2010; Doyle & Cicarelli, 1980; Fortin, 2004; Hemelt & Marcotte, 2011).

TABLE 3–Description of the Variables

Variable	Description	Expected Sign	Explanation
Applicants	The "demand" was calculated as total entering students at the undergraduate level divided by the percent of undergraduate applicants admitted		This is the variable that is used as the proxy for the demand for college/university education. It is calculated for the private and public institutions in the sample, as well as for all schools. The variable was calculated as total number of applications was not a variable that was available for the data set.
Tuition	Undergraduate in-state tuition and fees; the "price" of education	Negative	According to demand theory, the relationship between price and demand is negative; higher prices translate to lower demand for a good or service
Change in Financial aid	Change in the percent of undergraduate students on financial aid between the current survey and the previous survey (2010%-2005%) and (2005%-2001%)	Positive	An increase in the percent of students on financial aid could be a signal that the institution is offering more financial aid, which could entice more potential students to apply.
Public tuition	Mean tuition and fees at sample public institutions located in the census region of the school	Positive	Price of substitute good; higher public tuition should increase the demand for private education
Private tuition	Mean tuition and fees at sample private institutions located in the census region of the school	Positive	Price of substitute good; higher private tuition should increase the demand for public institutions
Barrons	Proxy for quality is Barron's competitiveness ranking, from 1-6 where 1=most competitive and 6=least competitive. For ease of interpretation, the values were reversed so 1=least competitive and 6=most competitive.	Positive	The most competitive schools should be the most desirable and have the most applicants
High Research	High research dummy equal to one if the institution is a research institution with very high research activity; proxy for quality	Positive	Research institutions with very high research activity could be considered higher quality institutions and so the demand for these institutions should be greater.
Power 5	Power Five dummy equal to one of the Power Five conferences and zero otherwise; proxy for publicity	Positive	Membership in these football conferences gives the institution greater publicity and should hence translate to higher demand
Year	Year dummy equal to one for 2010 and equal to zero for 2005.	Positive	In general, the demand for higher education has risen over time. Additionally, 2010 represents the end of the Great Recession and the beginning of a long and slow recovery. Fewer jobs could mean more potential students seeing college as a viable option (Allen & Shen (1999).

Although some measure of income is normally included in a demand function, it was omitted in this instance. Both the public and private schools included in the sample included out-of-state applicants. Because of this factor, including a measure of income for the state in which the school was located (Doyle & Cicarelli, 1980) would be misleading as applications were also being drawn from other states. The change in the overall economy (income) was proxied by the year variable, which indicated whether the data was from 2005 or 2010. Barron's ratings, which rate schools on their difficulty of admission, were also used as a measure of quality by Doyle and Cicarelli and by Pascarella et al. (2006). Smith (2009), as one of his measures of football culture, utilized the conference membership status of each institution in his study as a measure of athletic quality.

Originally we had planned on including a dummy variable indicating whether the college was public or private. However, tests for multicollinearity showed very poor statistics for the tuition and public variables. Including both variables in the equation yielded VIF statistics of 8.409 and 7.266 for tuition and the public dummy respectively. These were both high, and additionally the Pearson's correlation coefficient between these two variables was a very robust .89 ($p < .001$). To solve this problem, we decided to drop the public dummy from the overall equation but to also run separate regressions for private and public institutions. Hence, along with the demand for all colleges and universities in the sample, demand functions for private and public institutions were estimated separately. For these demand functions, variables representing average public tuition and average private tuition for the geographical census region of the institution for inserted into the demand equations for private and public institutions respectively (Leslie & Brinkman, 1987) as a proxy for price of a substitute good.

A. MODEL AND RESULTS – ALL COLLEGES AND UNIVERSITIES

A panel-type model was used to test the demand function, with a dummy variable representing the two different years. Because the model consisted of only two years, but with over 300 cross-sectional observations in each year, heteroscedasticity was a potential problem. Heteroscedasticity is often a problem in cross-sectional models. We tested for heteroscedasticity using the Breusch-Pagan test. According to the Breusch-Pagan test, the null hypothesis of homoscedasticity could not be rejected, with $\chi^2(6) = 9.684$, $p = .139$. Hence, heteroscedasticity was not a problem for the overall demand function, and no adjustments were needed. OLS appeared to be an appropriate methodology for analyzing the demand function. The model for all colleges and universities in the sample was estimated in OLS using equation (2). The resulting demand function is shown in Table 4.

TABLE 4–Demand Function: All Colleges and Universities, Dependent Variable = Number of Applicants

Variable	*β*	*SE*	*t*
Constant	8.039***	0.114	70.779
Tuition	-0.743***	0.046	-15.982
Barron's Rating	0.905***	0.095	9.537
Change in Financial aid	0.373***	0.092	4.036
High research dummy	1.308***	0.100	13.117
Power 5 dummy	0.293**	0.118	2.483
Year	0.350***	0.062	5.660
N	668		
R-squared	0.598		
Adj. R-squared	0.595		
F-statistic	164.305***		

(*t* statistics in parentheses) ***significant at 1% level; **significant at 5% level; *significant at 10% level

The overall model showed demand to be inelastic with respect to price (tuition). This was a particularly strong variable, likely because both public and private institutions were included in the model. As shown in Tables 1 and 2, the mean number of applicants for public colleges and universities was much higher than the mean number of applicants for private institutions. Since private institutions also had higher average tuition levels, this result was expected. Additionally, higher quality institutions, as proxied by higher Barron's ratings (the ratings were reversed so that higher ratings equated to the most competitive schools), attracted greater numbers of applicants, as did research institutions with very high research activity (another proxy for quality).

The change in the percentage of students receiving financial aid between the previous survey and the current survey was also a significant variable. This increase in the percent of students receiving financial aid may act as a signal that more (or less) aid is available to incoming students. Membership in a Power Five athletic conference attracted more applicants as well. Finally, demand was higher in the later year of the study (2010). This could be because demand for higher education has grown in general, or because at the tail end of the Great Recession/beginning of the long recovery jobs tended to be scarce and applying to college appeared a more attractive alternative to unemployment.

B. MODEL AND RESULTS–PRIVATE COLLEGES AND UNIVERSITIES

The results of the OLS estimation for private institutions also showed no evidence of heteroscedasticity. The results of the Breusch-Pagan test showed that the null hypothesis of homoscedasticity could not be rejected, with $\chi^2(6) = 6.594$, $p = .472$. The results of the regression are shown in Table 5.

The demand for private colleges and universities, when observed separately, did not seem to be influenced by tuition. The price of a private education (as proxied by tuition) was not a determinant of demand. Although tuition was a very strong predictor of overall demand, this may have been mainly serving as a proxy for the difference between public and private institutions. Between private institutions only, the price appeared to be much less important. Other factors appeared to be the main determinants of demand.

Quality, as approximated by the Barron's ranking of the institution, was an important determinant of demand, as was the other proxy for quality, the high research dummy variable. Changes in the percent of students receiving financial aid was also a significant predictor for private college applications. Publicity gained from being a member of a Power Five athletic conference was a positive influence on the number of applicants for private schools. The price of the substitute good, approximated by regional public tuition, was a significant determinant of demand, as higher tuition at public institutions in the region predicted a higher number of applicants to the private schools in the sample.

TABLE 5–Demand Function: Private Colleges and Universities
Dependent Variable = Number of Applicants to Private Schools

Variable	*β*	*SE*	*t*
Constant	5.098***	0.479	10.640
Tuition	-0.093	0.164	-0.567
Barron's Rating	0.786***	0.153	5.145
Change in Financial aid	0.312**	0.127	2.454
Public Tuition	0.537**	0.260	2.063
High research dummy	1.529***	0.131	11.684
Power 5 dummy	1.042***	0.198	5.275
Year	0.040	0.105	0.377
N	372		
R-squared	0.566		
Adj. R-squared	0.558		
F-statistic	67.998***		

(*t* statistics in parentheses) ***significant at 1% level; **significant at 5% level; *significant at 10% level

Again, the differences between private and public tuitions appeared to be more important in this model than variations between the private tuition levels themselves. Finally, the year was not a significant variable, hence indicating that the number of applicants to private institutions did not increase significantly between 2005 and 2010.

C. MODEL AND RESULTS – PUBLIC COLLEGES AND UNIVERSITIES

The Breusch-Pagan test was also run for the public school model, with no evidence of heteroscedasticity shown. According to this test, the null hypothesis of homoscedasticity could not be rejected, with $\chi^2(7) = 11.503$, $p = .118$, meaning that the null hypothesis of homoscedasticity could not be rejected and that no adjustments to the model were needed. The results of the OLS estimation for public institutions are shown in Table 6.

TABLE 6–Demand Function: Public Colleges and Universities
Dependent Variable = Number of Applicants to Public Schools

Variable	*β*	*SE*	*t*
Constant	6.919***	0.831	8.322
Tuition	-0.244*	0.136	-1.787
Barron's Rating	0.773***	0.106	7.278
Financial aid	0.187*	0.113	1.654
Private Tuition	0.222	0.289	0.769
High research dummy	0.736***	0.136	5.426
Power 5 dummy	0.294**	0.144	2.043
Year	0.136	0.110	1.234
N	295		
R-squared	0.517		
Adj. R-squared	0.505		
F-statistic	44.001***		

(*t* statistics in parentheses) ***significant at 1% level; **significant at 5% level; *significant at 10% level

As with the demand function for private institutions, the demand for public colleges and universities was not sensitive to changes in tuition at a 5% significance level, although in this case it was significant at a 10%

level. The demand function for public schools may be somewhat negatively influenced by price. However, because of the low level of significance, the results still seem to indicate that the effect of tuition on applicants is more influenced by the public-private spread in tuitions than by differences between individual public college tuition levels. As with private colleges, quality was important, as the number of applicants to public colleges and universities was positively influenced by quality as approximated by its Barron's ranking and being a high research activity university. Being a member of a Power Five athletic conference predicted a higher number of applicants as well.

The financial aid variable was also significant, but only at a 10% level. It did exhibit a positive relationship between a change in the percent of students on financial aid and applicants. The price of the substitute good, regional private tuition was not a significant determinant of demand. The year variable was not significant, showing that, for public colleges separately, the Great Recession may not have had an influence on demand.

D. MODEL AND RESULTS – COLLEGES AND UNIVERSITIES EXCLUDING RESEARCH UNIVERSITIES WITH VERY HIGH RESEARCH ACTIVITY

In all regressions run to this point, the high research dummy variable was significant with a positive sign. Students appear to select institutions with high levels of research activity regardless of whether the schools were private or public. Due to their high research activity, these schools all have very good academic reputations. These are the postsecondary institutions that are the most likely to attract students each year regardless of the state of the economy. These are the "top" universities, but what about the lower tier colleges and universities? Are they more sensitive to economic fluctuations? Are consumption factors more or less important at these institutions? In order to examine these questions, we re-ran both the overall model first eliminating those college and universities rated as "research universities – very high research activities" by Carnegie and then using only the very high research universities.

As with the previous models, the Breusch-Pagan was performed for the lower research institution model, with no evidence of heteroscedasticity shown. According to the Breusch-Pagan test, the null hypothesis of homoscedasticity could not be rejected, with $\chi^2(5) = 3.211$, *p* = .668. Therefore the null hypothesis of homoscedasticity could not be rejected, meaning that no adjustments were needed. The results of the OLS estimation of colleges and universities excluding those with high levels of research activity for the years are shown in Table 7.

TABLE 7–Demand Function: Private Colleges and Universities
Dependent Variable = Number of Applicants to Research Universities without Very High Research Activity

Variable	*β*	*SE*	*t*
Constant	8.314***	0.123	67.797
Tuition	-0.851***	0.051	-16.772
Barron's Rating	0.875***	0.098	8.926
Change in Financial aid	0.395***	0.105	3.763
Power 5 dummy	1.478***	0.242	6.104
Year	0.390***	0.067	5.828
N	537		
R-squared	0.423		
Adj. R-squared	0.418		
F-statistic	78.082***		

(*t* statistics in parentheses) ***significant at 1% level; **significant at 5% level; *significant at 10% level

The demand for education at non-high research institutions was inelastic, as tuition was again a significant variable. Higher tuition levels predicted lower numbers of applicants at the schools within this sample. As with the overall sample, this result may be reflecting the public-private tuition differential and its influence. Quality as proxied by the Barron's ranking remained a determinant of demand with higher rated schools predicting more applicants. Membership in a Power Five conference remained a positive determinant of demand in this model, as with previous models. A positive change in the level of students on financial aid was also a positive predictor of applicants. Finally, the year predicted more applicants for the schools in 2010 as compared to 2005.

E. MODEL AND RESULTS – RESEARCH UNIVERSITIES WITH VERY HIGH RESEARCH ACTIVITY

Lastly, a regression was run for research universities with very high research activity only. These are the schools with the highest Carnegie classification. The model again showed no evidence of heteroscedasticity, with $\chi^2(5) = 6.710$, $p = .243$. The null hypothesis of homoscedasticity could not be rejected, so no adjustments were needed. The results of the OLS estimation of research universities with high levels of research activity for the years are shown in Table 8.

TABLE 8–Demand Function: Dependent Variable = Number of Applicants to Research Universities with Very High Research Activity

Variable	*β*	*SE*	*t*
Constant	8.121***	0.354	22.962
Tuition	-0.323***	0.099	-3.249
Barron's Rating	1.035***	0.294	3.522
Change in Financial aid	0.100	0.175	0.570
Power 5 dummy	0.237**	0.110	2.163
Year	0.248*	0.135	1.837
N	130		
R-squared	0.200		
Adj. R-squared	0.168		
F-statistic	6.232***		

(*t* statistics in parentheses) ***significant at 1% level; **significant at 5% level; *significant at 10% level

The demand for education at high research institutions was inelastic, although the value of the elasticity shows the demand for high research institutions to be more inelastic than the demand for lower research institutions. The elasticity for the high research schools was 0.323 as compared to 0.851 for the lower research schools. Quality remained an important influence, as the Barron's ranking remained a determinant of demand with higher rated schools predicting more applicants. Membership in a Power Five conference was a positive influence on demand in this model as well. The financial aid variable was not significant; applicants to the highest level of research universities seem less influenced by financial aid factors. Finally, year was significant, but only at a 10% level. Possibly higher research institutions are less influenced by economic fluctuation than lower research schools.

V. Conclusion

When comparing both years of data for all colleges and universities, private and public institutions, and colleges with and without very high research activity, a few consistent patterns emerged. Tuition was a factor only as long as public schools and private schools were both included in the model. As soon as they were separated, tuition became insignificant (at the 5% significance level). This result seems to indicate that tuition differences between public and private institutions are much more important to the application process than differences within each category.

The cross price elasticity of demand between public and private schools, as proxied by regional private and public tuition in the public and private education models, did not appear to be an important determinant of demand for public schools, but was a positive influence on the demand for private colleges and universities. Although other research has found little evidence of a positive cross price elasticity of demand between private and public colleges (Hight, 1975; Knudsen & Servelle, 1978), the current results indicate a positive cross-price relationship could exist for private institutions only. The year was a positive influence on demand in some models, but not others. It seemed to have little influence when the public and private institutions were separated. The financial aid variable also varied in significance, being an important variable in most models, but not for the top research universities. Overall, the value of the financial variables varied in significance.

Consumption factors, however, appeared to be very important to all models. Quality was proxied by two measures: the (reversed in value) Barron's ranking and a dummy variable representing research universities with very high research activity. Quality as proxied by Barron's rating was a more important influence on demand in all models. The high research dummy was important in all of the models in which it was included as a predictor. In both cases, quality was a strong positive predictor of the number of applicants.

The other consumption variable included in the model was membership in a Power Five athletic conference. Membership was a positive influence on the number of applicants in all models as well. The idea that the publicity gained from participation in a major football conference can positively influence the number of applicants in those schools seems to be supported. This result strengthens the work of McCormick and Tinsley (1987) and Pope and Pope (2009) who found that success in football and basketball tended to increase the number of applicants to the successful schools. In conclusion, the results indicated that consumption factors such as being in a major athletic conference or having a strong academic reputation are important factors in the demand functions for colleges and universities, regardless of the condition of the overall economy.

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Post-Retirement Discounting in Estate Loss Calculations and the Net Discount Rate

Fred Abraham and David R. Hakes*

ABSTRACT. We show that the accumulations to an estate from premature death should be discounted from the time of projected death rather than from retirement. We provide evidence that in most cases an estate does not grow, and is most likely stable, from the time of retirement to that of projected death. We then calculate the overstatement of the loss to the estate when a forensic economist mistakenly discounts the accumulations to the estate from the time of retirement instead of projected death. We also demonstrate that the use of a net discount rate to discount from retirement to projected death overstates the loss to the estate because a net discount rate implicitly assumes a positive growth rate in the nominal estate from retirement to projected death. (E43, K13, J26)

I. Introduction

Forensic economists are often called upon to evaluate the loss to an estate because of premature death. Depending on circumstances, the elements of the loss can be many or few. This paper will focus on instances where the loss is confined to the loss to the estate. The loss to the estate is the present discounted value of the accumulation that would have been generated had the deceased experienced a typical work life and death. The analysis we present in this paper applies to the case of death to a child who had not entered the labor force or started a family. It also applies to those cases of a single adult with no dependent survivors. The analysis may also apply to other more complex cases. We have, however, chosen to address these simple cases in order to better focus on the specific issue which we will develop below.

Conceptually, calculating the present value of the estate loss begins with a starting income imputed to the deceased which is then allowed to grow until retirement age. Each year, a certain portion of that income is set aside and considered accumulation to the estate. These annual amounts are grown at interest until some future date of retirement. This accumulation is then discounted to the present. That sum is considered

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to be the present value of the loss to the estate because of the premature death. Note that this calculation requires the forensic economist to make assumptions regarding the treatment of the estate from retirement to projected death. First, should the estate be discounted to the present from the time of retirement or the time of projected death? Second, does the nominal value of the estate grow, stay constant, or decline from retirement to projected death?

With regard to the first question, because the estate is not realized until the time of projected death, forensic economists generally agree that the sum of the yearly accumulations should be discounted from the time of projected death rather than at retirement. Thus, while the mistake of discounting the estate from the time of retirement rather than death is rarely intentionally committed, we will show that this mistake is often accidentally committed due to the use of a common method of discounting. The second question regarding the nominal growth rate of the estate from retirement to projected death is not generally agreed upon. Therefore, we will address this issue below.

II. Post Retirement Accumulation Assumptions

There are several ways to treat the accumulation to the estate from the time of retirement to projected death. First, we can assume that the estate would continue to grow from retirement to projected death. Second, we can assume that the estate would remain constant. And third, we can assume that the estate declines. We will address these possibilities in nominal terms.

Assumption 1: Increased Estate Size after Retirement

Estates grow over time from two sources: Accumulations due to allocations from current income, and earnings on past accumulations. Since current income usually declines significantly in retirement it would be expected little additional contributions to the estate would accrue from this source but they could still occur. Earnings from past accumulation could be positive and contribute to the estate size so the estate at projected death could be higher than at retirement.

Assumption 2: Constant Estate Size after Retirement

Since current earned income usually declines after retirement and retirees still have living expenses, it is not unusual for retirees to live off any accrued pensions and Social Security benefits, frequently supplementing that with any income earned from past accumulations. In fact, it is not unusual for retirees to spend all income earned from an accumulation while making a point to not reduce the estate. Protecting the "nest egg" is a fairly common phenomenon. The nominal value of the estate at retirement is then equal to that at projected death.

Assumption 3: Decline in Estate Size after Retirement

In this case, in addition to living off any pensions, Social Security, and earnings from accumulation, some of the prior accumulation itself would be spent, resulting in an estate that is smaller at death than at retirement.

III. Evidence

Which assumption does the data support? The most cited study regarding wealth accumulation or decumulation after retirement is Hurd (1990). Utilizing data from the RHS (Retirement History Survey) he finds that singles have a reduction in their wealth in the first ten years after retirement of -36.4% for an annual rate of reduction of -4.5%. Couples have a reduction of -14.5% over the first ten years for an annual rate of reduction of -1.6%. Both groups together have a reduction of -27.3% over the first ten years after retirement. If we include housing in household wealth, the measure of the rate of decumulation is reduced, but both groups still have a reduction in their wealth, generating a combined reduction of -13.9% over the first ten years after retirement. Utilizing data from the HRS (Health and Retirement Survey) Poterba, et. al. (2011) find that there is a small decline in the financial assets for most households in the decades after retirement. Venti and Wise (2004) also find a small draw down of wealth during retirement. Smith, et. al. (2009) find that the middle three quintiles of the wealth distribution report relatively stable net worth in retirement, while the lowest quintile draws down its wealth and the highest quintile continues to accumulate.

In summary, there is strong evidence that the estate for most retirees is either stable or declining in the post-retirement period, except possibly for the highest quintile of the wealth distribution. It would appear Assumption 1 would be the least reasonable, occurring in, at most, about 20% of the cases studied.

IV. Differences in Estate Value Calculations

The summation of the present values of each annual accumulation is easily done in a spreadsheet. The evidence suggests that most of the time the nominal value of the estate stays approximately the same from retirement to projected death. That is, 60% of the time (middle three quintiles of the wealth distribution) assumption 2 is most supported by the data. *Therefore, under assumption 2, the present discounted value of the estate at projected death will always be smaller than the present discounted value of the estate at retirement.* Thus, calculating the present discounted value of the estate from retirement instead of from projected death overstates the estate loss. The problem of the overstatement of the estate loss is even larger under assumption 3 (that the nominal value of the estate actually declines during retirement) but we will limit our analysis to assumption 2, the most likely case supported by the data.

V. Magnitude of the Difference when Discounting from Retirement vs. Projected Death

We have argued that estates should be discounted from the time of projected death rather than from the time of retirement. Employing assumption 2 (the nominal value of the estate is constant from retirement to projected death) we calculate the amount of overstatement of the loss to the estate when the forensic economist mistakenly discounts the estate from the date of retirement instead of projected death. Table 1 shows the amount of overstatement depending on various values of the time between retirement and projected death and discount rates assuming the nominal value of the estate remains constant from retirement to projected death. For example, if the nominal discount rate used is 3% and the time between retirement and death is 12 years, the present discounted value of the estate should be reduced to about 70% of the value that would have been calculated had the estate been incorrectly discounted from retirement.

TABLE 1–Necessary Adjustments to Estate Present Value Discounting from Projected Death versus Discounting from Projected Retirement*

YEARS FROM RETIREMENT TO PROJECTED DEATH	NOMINAL DISCOUNT RATE 0.01	0.02	0.03	0.04	0.05	0.06	0.07
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935
2	0.980	0.961	0.943	0.925	0.907	0.890	0.873
3	0.971	0.942	0.915	0.889	0.864	0.840	0.816
4	0.961	0.924	0.888	0.855	0.823	0.792	0.763
5	0.951	0.906	0.863	0.822	0.784	0.747	0.713
6	0.942	0.888	0.837	0.790	0.746	0.705	0.666
7	0.933	0.871	0.813	0.760	0.711	0.665	0.623
8	0.923	0.853	0.789	0.731	0.677	0.627	0.582
9	0.914	0.837	0.766	0.703	0.645	0.592	0.544
10	0.905	0.820	0.744	0.676	0.614	0.558	0.508
11	0.896	0.804	0.722	0.650	0.585	0.527	0.475
12	0.887	0.788	0.701	0.625	0.557	0.497	0.444
13	0.879	0.773	0.681	0.601	0.530	0.469	0.415
14	0.870	0.758	0.661	0.577	0.505	0.442	0.388
15	0.861	0.743	0.642	0.555	0.481	0.417	0.362
16	0.853	0.728	0.623	0.534	0.458	0.394	0.339
17	0.844	0.714	0.605	0.513	0.436	0.371	0.317
18	0.836	0.700	0.587	0.494	0.416	0.350	0.296
19	0.828	0.686	0.570	0.475	0.396	0.331	0.277
20	0.820	0.673	0.554	0.456	0.377	0.312	0.258

*Table assumes no estate change after retirement

This correction is no trivial amount as the following examples in Table 2 show. For illustrative purposes, we provide simple examples for a death occurring at ages 20, 40 and 60. Our examples use a nominal rate of income growth of 2.5% and a discount rate of 4%, and an average accumulation rate of 10%. We assume a retirement age of 67. There are a variety of other variables that can be included but have been ignored for these examples. Including them as well as using different assumed values would alter the dollar values in the examples. It is not the point of this exercise to argue the merits of the assumptions. It is only to show how improper post retirement discounting can alter the amounts of a loss.

TABLE 2–Overstatement of Present Value of Estate Loss*

Actual Death	Annual Starting Income	Annual Accumulation	PV at Retirement	Age of Proj Death	PV at Proj Death	Loss Over Statement
20	$26,078	$2,608	$86,031	79.5	$52,691	$33,340
40	45,370	4,537	98,142	80.6	57,571	40,571
60	47,294	4,729	30,488	83.1	16,214	14,274

*Accumulation of 10% of gross income. Starting incomes from US Dept. Of Commerce, 2014.

For example, if a 40 year old deceased person is projected to earn $45,370 with an annual nominal increase of 2.5% and an accumulation rate of 10% until projected retirement at age 67, the present value of the estate discounted from time of retirement would be $98,142. Discounting from the life expectancy of 80.6 to present value yields $47,571 for an overstatement of the present value of the estate loss of $40,571.

VI. Implications of the Use of Net Discount Rates

Rather than do the calculations individually, that is, first do the growth and then the discounting, it has become common to use a net discount rate (NDR) to do the calculations simultaneously. Mathematically, the NDR is calculated by

$$\frac{(1+g)^t}{(1=i)^t}$$

where *g* is the nominal growth rate of the annual accumulation, *i* is the nominal discount rate, and *t* is the number of years of accumulation.[1]

The advantage of using a NDR is that it does two calculations simultaneously. It grows an amount and discounts the result in one step. However, using it to discount an estate from retirement to projected death makes implicit assumptions about post-retirement accumulation. That is, the use of a NDR *implicitly assumes the nominal value of the estate grows post-retirement*. But, recall that the evidence does not support a growing nominal value of the estate post-retirement for the average estate. Thus, the NDR overstates the value of the loss to the average estate.

The size of the overstatement of loss depends on the size of *g* and *i*. In the special case of assuming the nominal growth rate of the estate is exactly equal to the discount rate ($g = i$) the use of a NDR will generate the same present value at retirement as it would at projected death. Therefore, comparing this result to the baseline case of assuming no nominal growth in the estate from retirement to death (assumption 2 which is supported by the data) we find that the use of this special case NDR overstates the loss to the estate to be precisely equal to the values generated in Tables 1 and 2. If the assumed growth rate is less than the discount rate, the overstatement will be less than that demonstrated in Tables 1 and 2, but a NDR will still generate an overstatement because of the implicitly assumed positive nominal growth to the post-retirement estate. The only case when the use of a NDR fails to overstate the loss to the estate is when the NDR is set equal to the discount rate, which implies that the growth in the estate from retirement to projected death is zero. That is, this case reverts to the case of no nominal growth in the post retirement estate.

For all of these reasons, we argue the forensic economist should specify both the assumed nominal growth rate and the assumed discount rate when using a NDR. Then the post-retirement growth in the nominal value of the estate can explicitly be held to zero while the estate is discounted from retirement to projected death and the loss to the estate will not be overstated.

VII. Summary

We argued the accumulations to an estate from premature death should be discounted from the time of the projected death rather than from retirement. We cite evidence that in most cases an estate does not grow, and is most likely stable, from the time of retirement to that of projected death. We then calculate the overstatement of the loss to the estate when a forensic economist mistakenly discounts the accumulations to the estate from the time of retirement instead of projected death. We also demonstrate that the use of a NDR to discount from retirement to projected death overstates the loss to the estate because a net discount rate implicitly assumes a positive growth rate in the nominal estate from retirement to projected death. Indeed, in the special case of a NDR where the growth rate equals the discount rate, the overstatement is precisely equal to that of mistakenly discounting the estate from the time of retirement. If the average estate actually declines from retirement to death, then the use of a NDR overstates the loss to the estate even more than we have argued in this paper.

We argue that forensic economists should specify both the growth rate and the discount rate when using a NDR. This allows for correct calculation of the estate in the post retirement period by holding constant the nominal value of the estate. In some cases, the difference between the technically correct results and those obtained from the use of a NDR may be small. But opinions of forensic economists are carefully scrutinized and subjected to challenging debate. If a mistake is made in reasoning, it can call into question the credibility of all statements made, including an entire report. Thus, it is of critical importance that calculations be methodologically correct.

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Endnotes

1. It is sometimes convenient to calculate a NDR by simply subtracting g from i. While not strictly mathematically correct, the resulting differences in calculations are not large. The appropriate NDR has been the subject of considerable discussion and debate. As a result, the National Association of Forensic Economics regularly surveys its membership as to what values they are using, and responses vary. It is not the point of this paper to delve into the appropriate NDR but only to remind the reader it does ultimately and critically depend on the values assigned to g and i.

Book Reviews

Edited by Robert Herren

Tax Systems. JOEL SLEMROD AND CHRISTIAN GILLITZER. Cambridge, MA: The MIT Press, 2014 Pp. x, 223. $30.00

Tax systems are consistently on the mind of academics and policymakers. Traditionally, optimal tax theory involves implementing a tax that minimizes the deadweight loss of taxation. The theme of Tax Systems is that such an approach is insufficient. A complete theory of optimal taxation would incorporate issues such as tax avoidance and evasion, deterrence, the administrative costs associated with collecting the tax, in addition to the elasticities traditionally considered. Enriching the optimal tax model to include these issues in a full system of taxation is the subject of this book.

Joel Slemrod and Christian Gillitzer break their book into four parts. Parts 1 and 2 provide an overview of the issues that need to be considered in an optimal tax system. This part begins with an overview of the optimal tax model that most economists are familiar with. The authors state that the taxes implied by the model are administratively infeasible because such a system would involve a different tax rate for every different good being taxed. The authors then discuss the practical considerations of a tax system, beginning with a theoretical analysis of tax evasion. The authors use a model of tax evasion developed by Michael G. Allingham and Agnar Sandmo in which taxpayers maximize their expected utility from tax evasion. As might be expected, the amount of evasion depends on the wage rate, the tax rate, and the probability of being caught evading taxes. Extensions of this frame work are considered, which include allowing for differences in underreporting income versus underreporting the tax liability and for labor income earned in the informal economy.

Empirical evidence for the degree of evasion is presented, though as the authors point out, it is difficult to find data on how much taxpayers are evading the taxes they owe. According to IRS estimates from random audits, tax evasion costs the U.S. Treasury just under $400 billion per year. One-third of this sum stems from the underreporting of income that has minimal information reporting, such as sole proprietor income, royalties, rents, and so forth. Only one percent of underreported income stems from underreported wage and salary income that would be reported on a W2 form. The authors state that in order to minimize evasion, the incentives for the income payer and payee to misreport income information would have to conflict. For instance with W2 wage income, the firm would have an incentive to overstate wage payment to minimize the corporate income tax paid while the worker would have incentive to understate wage income to minimize the personal income tax liability. These two conflicting incentives cancel out, resulting in accurate information being reported. The same is true with a valued-added tax system.

The authors distinguish between tax evasion and tax avoidance, which is the legal means by which taxpayers reduce their tax liability. The authors focus primarily on two forms of tax avoidance: the time shifting of activities to take advantage of changes in the tax code and using financial assets to take advantage of differential tax treatment across different financial assets. The Tax Reform Act of 1986, which lowered the top personal marginal income tax rate below the corporate tax rate, led to many C corporations to be re-characterized to S corporations. Arbitrage can be used to take advantage of differential tax treatment of different types of financial assets, resulting in substantial tax savings.

A discussion of administrative and compliance cost of taxation rounds out Part 1 of the book. Estimates for the administrative costs for the OECD countries are presented. Because administrative costs are largely fixed costs, administrative costs as a percentage of tax revenue are lower for large countries than for small countries. For instance, administrative costs are 0.6 percent of net tax revenue for the United States, compared to 1.1 percent for the Netherlands in 2009.

The cost of complying with the tax system is hidden and difficult to estimate, but important to consider. In the United States, compliance with the personal income tax is estimated to cost 10 cents per dollar of tax revenue raised, while complying with the corporate income tax is estimated to cost 23.4 cents per dollar of tax revenue raised. Administration and compliance costs lead to an interesting discussion regarding how the statutory tax incidence is not independent of the tax liability, in contrast to the standard textbook model. If administrative costs are lower if the tax incidence is placed on the seller versus the buyer, because there are fewer sellers than buyers, then placing the statutory tax incidence on the sellers will lower the overall cost of the tax system.

In Part 3, the authors reanalyze the optimal tax model with these building blocks in place. Including issues such as evasion and administration costs in the standard model yields novel results. There is a trade-off between the size of the tax base and the amount of administrative costs borne by the taxing authority. A broad tax base minimizes deadweight loss but has substantial administrative costs while a narrow tax base is easy to collect but potentially has large deadweight loss. Including administrative costs in the optimization of the standard tax model allows the policymaker to strike the optimal balance between the breadth of the tax base and size of the administrative costs.

Including administrative costs in the standard tax model also allows policymakers to find the optimal audit rule. In a model without administrative costs, the optimal audit rule is such that revenue to the public treasury is maximized. The authors illustrate that in a model with administrative costs, the optimal audit rule does not result in revenue maximization because that rule would involve spending a dollar on administrative costs in order to raise a dollar of revenue from an avoidant taxpayer.

Part 3 is fairly technical with the authors utilizing multivariate calculus to optimize the tax model that includes administrative costs, compliance costs, taxpayer evasion and avoidance, and so forth. Researchers in optimal tax theory who want to be up-to-date on the state of the field will want to read Part 3 closely. The authors provide enough detail in the mathematical derivations that an interested researcher should be able to recreate the results without too much difficulty. Casual readers can skim through the derivations to obtain the intuition behind the results. The authors do a good job motivating their results and discussing the intuition behind them. Parts 1 and 2 also utilize calculus, but less so than Part 3. Parts 1 and 2 provide more exposition for the models and present the empirical results from researchers who have tried to measure issues such as the administrative and compliance costs of taxation, and the behavioral elasticity in response to taxation. Casual readers and economists not specializing in optimal tax theory will want to focus their attention on these two parts.

The authors wrap-up the book in Part 4 with looking on what tax systems will look like in the future with better information and filing technologies, sales taxes for online versus brick-and-motor stores, and multiple tax jurisdictions and tax havens.

This book does not directly address proposed income or corporate tax reforms though optimal tax models certainly have value to add to the discussion of what tax reform should look like. Issues such as an income tax versus a value-added tax, whether deductions such as the mortgage interest deduction are worthwhile, corporate tax reform, and the economics of related issues such as the border adjustment tax are not directly dealt with. However, this book would give the reader a sound foundation on which to further examine taxation issues such as these. Economists who want to be up-to-date on the state of the research on optimal tax theory from the leading researcher in the field should check out *Tax Systems*.

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The Mobility of Students and the Highly Skilled. Ed. MARCEL GERARD AND SILKE UEBELMESSER. Cambridge, MA: The MIT Press. 2014. Pp. vi, 346. $ 35.00.

This collection of essays is quite timely, given recent political events and policy changes in both the European Union (EU) and the United States. Several papers delve into the "brain gain/brain drain" debate. Other papers discuss how the gain/drain phenomenon might impact a country's decision to fund higher education. While the essays as a group focus on the EU, there is some mention of labor mobility and immigration issues in regard to the United States, as well as other non-EU countries. Marcel Gerard is at the Catholic University of Louvain, while Silke Uebelmesser is at the University of Jena.

After Chapter 1's introduction, summarizing some of the book's results, Chapter 2, written by Gabril J. Felbermayr and Isabella Reczkwoski, employs a gravity-type model to investigate the extent to which the number of international students in a host country determines the number of highly-skilled (university-educated) migrants in the host country. Using a data set based largely on UNESCO numbers, the coauthors find that the elasticity of the "stock of highly educated migrants with respect to the international student body" (p. 45) is about 0.09. However, it is higher for Anglo-Saxon countries, in part because of easier work visa policies in some cases (e.g., Canada), and in part because English has become the "lingua franca" of international business, among other reasons. The coauthors' results also indicate that migration of highly skilled workers may induce the migration of lower-skilled individuals (e.g., family members).

Chapter 3 focuses on a particular labor market, namely the United States Ph.D. market for economists, written by Linda Bouwel and Reinhilde Veugelers. The study's data base contains information on 375 European students who obtained their doctorates at United States universities between 1992 and 2006. Seventy percent of these stayed in the US after graduation; those whose education was funded by EU sources were more likely to return to the EU, however. Graduates of "top" US economics programs (as listed in the paper) were more likely to stay in the US compared to others. The researchers note, however, that economics PhDs are more likely to stay in the US compared to other disciplines.

The fourth chapter, penned by Elisabetta Marinelli, Ana Fernandez-Zubieta and Susana Elena-Perez, looks at the EU market for academic researchers in five EU countries: France, Germany, Italy, the Netherlands and the United Kingdom. The coauthors note that "inbreeding" is a problem with European institutions that hinders mobility. Analyzing SIM-ReC project data, they determined that "stayers" – those that received in PhD in one country and stayed in that country, and "returners"—those that took a job in a country different from where they were educated, but subsequently returned to their PhD-granting country--are most likely to find permanent positions compared to others. German researchers are the least likely to find permanent positions. Of the 1548 cases, 59 percent were stayers and 20 percent returners. Natural science PhDs are more mobile than those of other disciplines.

David E. Wildasin's contribution (Chapter 5) starts to shift the focus to higher education funding. He notes that aging populations in OECD countries are putting considerable fiscal stress on their governments, impacting education funding. Because people carry their human capital with them, the country educating them might lose them due to emigration. Because better educated persons usually have higher incomes, and therefore pay more in taxes, emigration can have negative fiscal consequences. However, declining birth rates in developed countries mean that these countries need immigrants to maintain their (tax paying) work forces.

Wildasin outlines the “standard” neoclassical model of migration (labor flows between countries or regions until values of marginal products are equalized). He notes that this model is a long run, comparative static model, while in “real life” migration is a very gradual process. He develops a model consisting of perfectly mobile (and complementary) capital and skilled labor, and immobile unskilled labor. Imposing a tax on skilled labor gradually induces labor emigration and capital outflow, and eventually declining returns to unskilled labor. Wildasin graphs how this plays out over time, namely over a considerable number of years.

Gerard and Ubelmesser’s Chapter 6 examines how higher education is financed when university students and graduates are internationally mobile. They look at the EU’s Erasmus program that allows EU students to study in another EU country, in many cases (excluding the United Kingdom (UK), which charges tuition) for “free.” However, these exchanges are not “balanced,” creating externalities: for example, a German student who could not gain admittance to a German medical school could opt to attend (say) an Austrian one, even though he intends to practice medicine in Germany. Gerard and Ubelmesser note that while this “unbalancing” might call for centralized (EU-level) education financing, the reality is that education is funded at the national (decentralized) level; the challenge is then to find decentralized financing schemes that mimic a centralized one. Since most benefits to higher education are private benefits to educated individuals, using a game-theoretic context, the coauthors discuss how combinations of tuition fees and taxes might accomplish such. This can include having a “originating country” principle (the country of the student’s citizenship pays, regardless of where the student studies, with possible limits on the number of students so supported), having income-contingent loans to cover tuition, as well as other policies. Financing issues are further discussed by Nicholas Barr in Chapter 7.

Income-contingent loans (ICL) to finance higher education are covered in Chapter 8 by Elena Del Ray and Maria Racionero. ICLs reflect (as noted above) that most benefits of higher education accrue privately; at the same time, ICLs provide some insurance to individuals who eventually work in relatively low paying occupations. Australia, New Zealand, the UK, the Netherlands and Sweden have variations of such. Risk-pooling ICLs are entirely financed by students (where repayments are calculated to cover those students with low incomes), while risk-sharing ICLs involve some amount of taxpayer subsidy. Using a game-theoretic perspective, the coauthors conclude that in almost all cases electorates will prefer the former. Emigration can create problems for ICLs, unless repayment can be enforced abroad.

Richard Murphy (Chapter 9) examines higher education in the UK. Under EU regulations, UK institutions must charge the same tuition to both UK and EU students (which might change under Brexit). However, UK schools can charge higher tuition to non-EU students, which might give these institutions additional funds to expand.

Chapter 10 (by Alexander Haupt, Tim Krieger and Thomas Lange) examines brain gain/brain drain issues. They argue that the host country can benefit from educating international students if some of those remain in the host country (brain gain); originating countries can also benefit from sending (and financing) their students' foreign education if enough of their students return to the originating country. However, if the "permanent migration probability" is too high, the originating country suffers a brain drain.

The last chapter (written by Luisa Gagliari) looks at how immigration of highly skilled workers impacts innovation in the United Kingdom, where the fraction of firms that are "innovative" in so-called "travel to work areas" (local labor markets) is related to immigration to those areas; the author finds a statistically significant relationship.

Overall, this book is an interesting read. Reference is made occasionally to the United States experience (say with interstate migration). Several issues raised in this tome are applicable to debates over US college financing, especially concerning ICLs (maybe as replacements for current college lending). Besides being a good reference for economists interested in education and labor markets, the book should also be of value to others concerned with education policy.

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Bootleggers and Baptists: How Economic Forces and Moral Persuasion Interact to Shape Regulatory Politics, ADAM SMITH AND BRUCE YANDLE. 2014. Washington, D.C.: Cato Institute. ISBN 978-1-939709-36-3. $24.95.

Bootleggers and Baptists is a colorful metaphor that may spark perhaps some religious connotations. However, it is just a colorful metaphor that describes the regulatory process in the United States that some people may deem as a burden. This book describes the dichotomy between the demands of the progressives to demand bigger government to solve problems versus the conservatives that believe bigger corporations is the way to go. This book attempts to answer the following question: where do economic regulations come from? Typical citizens would automatically presume the regulation would be promulgated by the actions of the President or Congress. However, the authors contend that the answer is more complicated than that. In economics textbooks, the general notion for the development of regulations is the correction of market failures. However, the authors argue that promulgation of regulations is caused by, and further shaped by, a combination of two distinct groups: Baptists and Bootleggers. This distinction between the Bootleggers and Baptists was espoused some 30 years before the publication of this book. In 1983, Bruce Yandle published an article in the journal, Regulation that distinguishes between these two groups. Yandle noted that public policies tend to be supported by "bootleggers," who saw their incomes increase as a result of a particular policy (as bootleggers did under Prohibition and under Blue Laws), and "Baptists," who supported public policies for moral reasons (Baptists tended to support prohibition and Blue Laws because they believed that alcohol was bad).[1]

The authors contend that these two groups are often at the source of the call for economic regulations, and how these regulations should be developed. From the standard public choice theory, special interests (the bootleggers) would influence the politicians and the regulators via campaign contributions and further their interests through the use of lobbyists. After receiving these influences, the regulations would be promulgated often in their favor. Alas, the costs of these regulations are dispersed over millions of people that the people who would hardly know its impacts at times. While reading this book, some readers may wonder including me how it is either big corporations or small special interest groups can gain or influence political influence when the rest of the public struggle to be heard. The concepts presented, along with easy to follow examples, such as Troubled Asset Relief Program (TARP), the Affordable Care Act (ACA) or commonly known as Obamacare, helps increase anyone's understanding of how our political system works.

Adam Smith and Bruce Yandle argue that successful regulation sometimes requires "a respectable public-spirited group seeking the same result [to] wrap a self-interested lobbying effort in a cloak of respectability" (p. viii).

The authors describe four strategies which Baptists and Bootleggers often adopt to advance their self-interests:

1. **The covert strategy.** A Bootlegger lobbies vigorously for a policy but adopt the stance and rhetoric of a Baptist are adopted. A good example to illustrate this: trade restrictions are seeked by an industry as a means to protect consumers from low quality goods imported from abroad. The outcome of this stance results in reduced competition and higher prices passed onto the consumers.
2. **The non-cooperative strategy.** Given a division within one of the groups, one party to that division allies with the other group. For example, an industry characterized by new and old technologies might see new technology firms ally with a Baptist group to address the social ills that still exist in the older firms.
3. **The cooperative strategy.** Baptists and Bootleggers united in a direct common cause. A good example would be the political alliance of large retailers, large insurance firms, unions, and health-care activists to support the Affordable Care Act (ACA). The ACA promised greater access of health-care to everyone. Consequently, this expanded healthcare coverage becomes quite profitable for these firms.
4. **The coordinated strategy.** This strategy requires a third party, usually via political leadership, to form a political coalition as a means to bring the groups together. As an example, President Clinton brought the housing industry and home ownership activists together to pressure other groups to change the lending standards as a means to increase homeownership in the United States.

The authors delve deeply about the derivations of their motivations and their incentives of the Bootleggers and the Baptists. As discussed in the book, the explanations for the Bootleggers can be attributed to the Public Choice theory as espoused by Gordon Tullock. On the other hand, the explanations for the actions of the Baptists are a bit more complicated, and the explanations have covered the auspices of economic thought ranging from Adam Smith to Richard Dawkin's theory.

The first half of this book delves into an enlightened discussion about the Bootleggers and the Baptists and their interests. The authors, then, supplement this discussion with case studies in the second half of the book. The case studies revolve around the regulations of alcohol, tobacco, and drugs, but then present an overview of the climate change regulations, the Troubled Asset Relief Program (TARP), and the Affordable Care Act. These case studies provide a good supplementary balance of the discussion in the first half of the book. The readers will gain quite a view of the regulations passed and how they came about.

After reading this book, readers will gain a greater understanding how this process works and clearly see the problems of the current system. Many readers will have a greater disdain towards this present system. That is, knowing the workings concerning how the system works would lead readers to know that alterations of the current practices are necessary as a means to create a representation in law-making in the United States. In other words, the government is created to beholden to its citizens and not the reverse as revealed by this eye-opening book. Given the benefits or at least some benefits received by the Bootleggers and the Baptists, readers may develop a greater disdain towards this process and may even wonder if this present system will ever change. Now the latter begs the question, given the benefits received by such interests, can the present system ever be reformed, especially with the arrival of the Trump Administration?

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