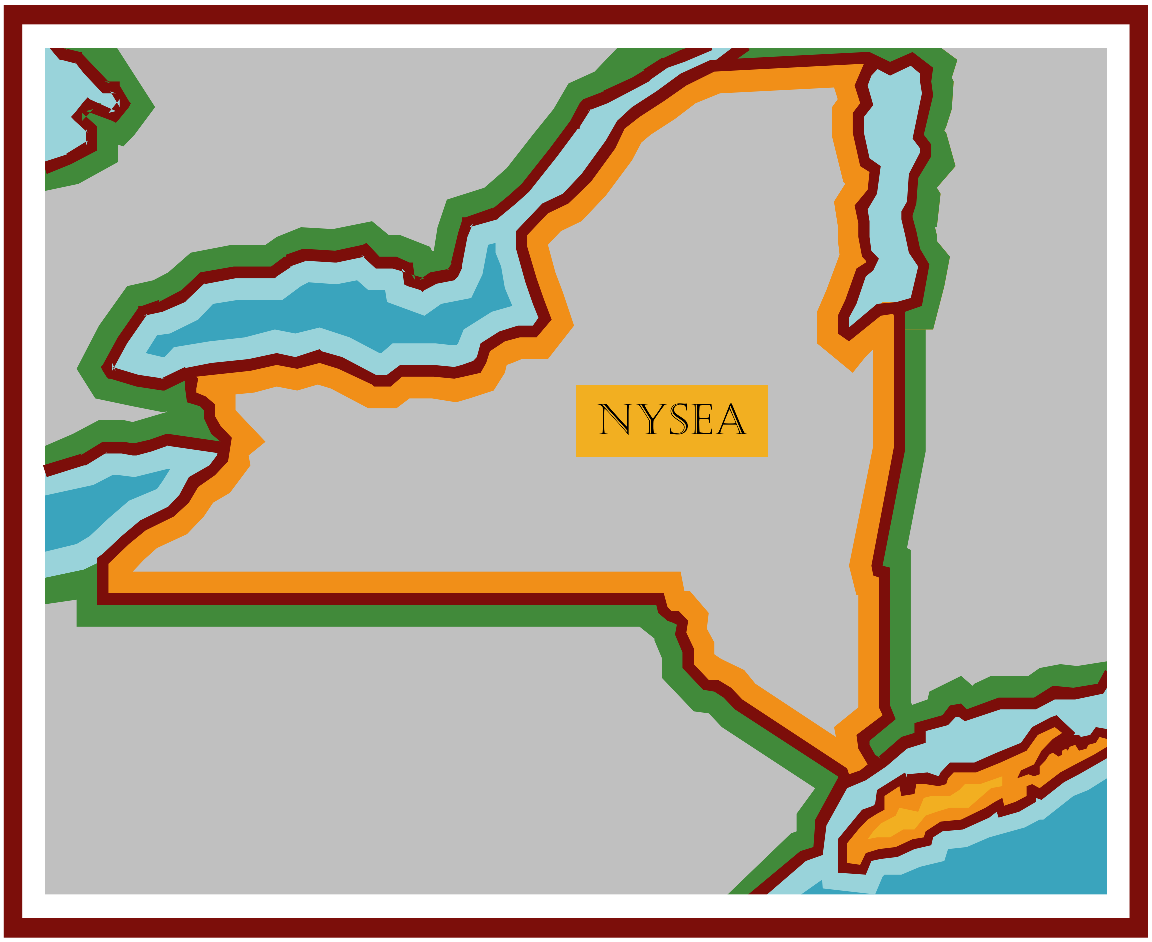
NEW YORK ECONOMIC REVIEW



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CONTENTS

ARTICLES

Shortfall Risk in Long-Term Hedging with Short-Term Future Contracts: A Two-Commodity Case
Carynne Litcher, Chunhui Yu, Xu Zhang……………………………………………………………..5

The Determinants of Draft Position for NBA Prospects
Brent Evans and Joshua Pitts…………………………………………………………………….22

Thoreau's micro theory prescience in *Walden*, Chapter One: 'Economy'
Jeffrey Wagner……………………………………………………………………………………38

Referees……………………………………………………………………………………………54

EDITORIAL

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Shortfall Risk in Long-Term Hedging with Short-Term Future Contracts: A Two-Commodity Case

Carynne Litcher*, Chunhui Yu*, Xu Zhang**

*Department of Mathematics, Farmingdale State College
**Department of Economics, Farmingdale State College

ABSTRACT

The price volatilities of the commodities expose commodity trading companies to the risk of big financial losses and force them to combat the risk with a spectrum of hedging strategies. In this paper, we study strategies to reduce shortfall risk in long-term hedging with short-term futures contracts. Our main contribution to the literature is extending Glasserman's model (2001) to a two-commodity scenario and providing numerical solutions for risk analysis across alternative hedging strategies to minimize either running risk or average risk. In the end, we illustrate a scenario when optimal average risk is superior to optimal fraction strategy if investors wish to receive large returns at the end of the hedging horizon.

1. INTRODUCTION

Large price fluctuations in the commodity markets can bring devastating losses to commodity trading companies, buyers, sellers, importers and exporters. These trading parties purchase or utilize crops, metals, crude oil and a variety of other commodities in order to sell them or produce other final products. They make a profit between the prices at which they purchase and sell minus any costs incurred before selling the commodities or refined products. The price volatilities of the commodities amplify the risk facing commodity trading companies and force them to combat the risk with a spectrum of hedging strategies. However, firms using the futures market to hedge the price risk must pay a premium, which may negatively impact a company's profit margin to some extent. For instance, Delta Airline CEO Ed Bastian admitted "a loss over $4 billion cumulatively on oil hedges over the last eight years" during a Bloomberg interview in 2016 and fuel accounts for around 23 to 33 percent of Delta's total costs. In addition, in late 1993 and early 1994, one of Germany's largest industrial conglomerates Metallgesellschaft (MG) reported a $1.3 billion loss suffered from a flawed hedge strategy. Apparently, MG attempted to hedge long term flow commitments for oil by sequentially stacking short dated (nearby) futures with each stack settled after one period. Mello and Parsons (1995) provided a detailed description of these contracts. The precipitous decline in oil prices in late 1993 caused funding problems. Upon learning of these circumstances, MG's board of supervisors instructed MG's new managers to begin liquidating MGRM's hedge and to enter into negotiations to cancel its long-term contracts with its customers. This action further complicated matters. The collapse of MG has received much attention in both academia and the financial press. Culp and Miller (1994, 1995) claim that the firm employed a prudent strategy of hedging long-term energy delivery obligations with short-term futures and swaps. In these authors' assessment, the MG bankers' operating mistake was the major reason for the crisis. Mello and Parsons (1995) indicates that the firm's energy

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market trading was rashly speculative and pointed out issues regarding basis risk, and the maturity structure of the hedge.

Glasserman (2001) focuses instead on a simple mathematical model of hedging long-term commitment with short-term futures contracts in the one-commodity case, where he investigates MG's rolling stack hedging strategy and develops several other theoretically improved hedging strategies based on the concept of running risks. One major contribution of this paper is extending Glasserman's work to a two-commodity case and providing numerical solutions for risk analysis across alternative strategies including no hedge, the rolling stack hedge, the combination hedge and the optimal fraction hedge. We also analyze the hedging strategies to minimize average risk, as introduced in Larcher and Leobacher (2003) and Garcia and Yu (2015), for a two-commodity case. The results of this work can be applied to industries such as the US energy industry; most U.S. energy companies produce both crude oil and natural gas and use WTI Crude Oil and NYMEX Natural Gas Futures contracts to offset the risk of any adverse price movements in the global markets. Additionally, it can also be applied to foreign exchange markets where international companies are exposed to two or more foreign currency risks.

The rest of the paper is organized as follows. Section two surveys the literature on optimal hedging strategies for different measures of risk. Section three demonstrates the mathematical analysis of long-term hedging with short-term futures contracts in a two-commodity case. Section four and section five discuss two hedging objectives and provides numerical solutions to four hedging strategies. Section six concludes.

2. LITERATURE REVIEW

Hedging as a valuable risk management strategy often is used to work against adverse price movements of commodities. As discussed in the benchmark work of Glasserman (2001), a mathematical model is introduced to study a scenario involving hedging a long-term commitment with short-term future contracts in a one-commodity case. Specifically, a number of hedging strategies, including no hedge, the rolling stack hedge, and the optimal fraction hedge are discussed in the mathematical setting. In the rolling stack hedging strategy, futures contracts are rolled into the next maturity as they expire, but the number of contracts is decreased over time to reflect the decrease in the remaining commitment in the supply contracts. A primary objective of such a hedging strategy is to protect the firm from the effects of large price fluctuations. In the simple single-factor model, Glasserman (2001) indicates the rolling stack hedging strategy completely eliminates the effect of spot price fluctuations, at least at the end of the hedging horizon. However, early in the life of the hedge, the use of short-dated contracts increases the risk of a cash shortfall. Moreover, Glasserman derives the numerical effect of spot price fluctuations and argues that comparing spot risks tends to understate the real short-fall risk that arises from the hedge. Indeed, one of Glasserman's main conclusions, based on a result on Gaussian extremes, is that the unhedged variance should be compared with the running maximum of the hedged spot variance (running risk).

The search for an optimal strategy to reduce the running risk in hedging a long-term supply commitment with short-dated futures contracts leads to a class of intrinsic optimization problems. Larcher and Leobacher (2003) gives an explicit analytic solution for this optimization problem if the market price of the commodity

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is based on a simple Gaussian model. Leobacher (2008) generalizes the work of Larcher and Leobacher and provides solutions to more general models, i.e. a mean reverting model and geometric Brownian motion as well as allowing for interest rates greater than 0. Wu, Yu and Zheng (2011) derives an explicit solution to the optimal deterministic strategy to reduce the running risk in hedging a long-term commitment with short-term futures contracts under the constraint of terminal risk. This study extends Glasserman's one-commodity case to a more realistic two-commodity model. Additionally, to minimize the running risk, we provide numerical solutions to alternative hedging strategies and also graphically illustrate the comparison. Moreover, we demonstrate a scenario where the optimal average risk strategy is superior to the optimal fraction strategy if investors wish to receive large returns at the end of the hedging horizon. To the best of our knowledge, this study is the first attempt to numerically and graphically analyze and illustrate alternative hedging strategies given two different optimization goals in a two-commodity setting.

3. MATHEMATICAL ANALYSIS

We explore a two commodity case in which a firm commits itself to supplying two commodities (commodity 1 & 2) with fixed price a_{1t} and a_{2t} at time $t\epsilon[0,1]$ and the market price of these two commodities S_{1t} and S_{2t} satisfies $dS_{1t} = \mu_1 dt + \sigma_1 dB_t$ and $dS_{2t} = \mu_2 dt + \sigma_2 dB_t$. Here, μ_1 and μ_2 are the drift coefficient; σ_1 and σ_2 are the diffusion coefficient; B_t is the standard Brownian motion process. If the hedging strategy is to purchase continuously G_{1t} short term futures for commodity 1 and G_{2t} short term futures for commodity 2 with lifetime dt at time t, then the unhedged cash flow and payoff from the hedging strategy over the time interval $[t, t+dt]$ satisfies the following (Please see Appendix B for references):

$$C_{1t} = \int_0^t \left(a_{1s} - S_{1s}\right) ds \quad (1)$$

$$H_{1t} = \int_0^t G_{1s}\left(\mu - b_s\right) ds + \int_0^t G_{1s}\sigma_1 dB_s \quad (2)$$

and

$$C_{2t} = \int_0^t \left(a_{2s} - S_{2s}\right) ds \quad (3)$$

$$H_{1t} = \int_0^t G_{2s}\left(\mu - b_s\right) ds + \int_0^t G_{2s}\sigma_2 dB_s \quad (4)$$

where b_{1t} and b_{2t} are the basis of the futures.

If $a_{1t}, a_{2t}, \mu_1, \mu_2, G_{1t}, G_{2t}, b_{1t}, b_{2t}$ are deterministic, assuming $T = 1$ and σ_1, σ_2 are constants, letting $g_1(s) = G_1(s) + s$ and $g_2(s) = G_2(s) + s$, where s is the time variable in the integral from time 0 to time t, we have the exposure and spot variance of hedged cash flows:

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$$C_{1t} + H_{1t} - E\left(C_{1t} + H_{1t}\right) = \int_0^t \sigma_1 \left(g_1(s) - t\right) dB_s \tag{5}$$

$$C_{2t} + H_{2t} - E\left(C_{2t} + H_{2t}\right) = \int_0^t \sigma_2 \left(g_2(s) - t\right) dB_s \tag{6}$$

$$Var\left(C_{1t} + H_{1t}\right) = \sigma_1^2 \int_0^t \left(g_1(s) - t\right)^2 ds \tag{7}$$

$$Var\left(C_{2t} + H_{2t}\right) = \sigma_2^2 \int_0^t \left(g_2(s) - t\right)^2 ds \tag{8}$$

Let $D_k = C_{1t} + H_{1t} + C_{2t} + H_{2t}$. Then, the spot variance is given in equation 9:

$$\mathrm{Var}\left(D_t\right) = \sigma_1^2 \int_0^t \left(g_1(s) - t\right)^2 ds + \sigma_2^2 \int_0^t \left(g_2(s) - t\right)^2 ds + 2\sigma_1\sigma_2 \int_0^t \left(g_1(s) - t\right)\left(g_2(s) - t\right) ds \tag{9}$$

As introduced by Glasserman, the running risk, which is defined as the maximum of the hedged spot variance up to time t, can be measured by the following equation:

$$R(\sigma_t^2) = \max_{0 \le s \le t} Var(D_s).$$

4. SPOT VARIANCE AND RUNNING RISK

Clearly if $G_1(s) = 0$ and $G_2(s) = 0$, there is no hedge, and the spot variance becomes the following:

$$Var\left(D_t\right) = \sigma_1^2 \int_0^t \left(s - t\right)^2 ds + \sigma_2^2 \int_0^t \left(s - t\right)^2 ds + 2\sigma_1\sigma_2 \int_0^t \left(s - t\right)^2 ds \tag{10}$$

If $G_1(s) = 1 - s$ and $G_2(s) = 1 - s$, which is called the rolling stack hedge, the number of futures to be held is gradually reduced so that the spot variance at the terminal date (i.e.t=1) is zero. In that case, the spot variance is given in equation 11:

$$Var\left(D_t\right) = \sigma_1^2 \int_0^t \left(1 - t\right)^2 ds + \sigma_2^2 \int_0^t \left(1 - t\right)^2 ds + 2\sigma_1\sigma_2 \int_0^t \left(1 - t\right)^2 ds \tag{11}$$

For a combination case of the rolling stack and no hedge strategies, where $G_1(s) = 1 - s$ and $G_2(s) = 0$. Equation 12 gives the spot variance in this case:

$$Var\left(D_t\right) = \sigma_1^2 \int_0^t \left(1 - t\right)^2 ds + \sigma_2^2 \int_0^t \left(s - t\right)^2 ds + 2\sigma_1\sigma_2 \int_0^t \left(1 - t\right)\left(s - t\right) ds \tag{12}$$

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We are also interested in a fraction strategy, which is a modified rolling stack strategy carried out throughout the whole time interval $[0, 1]$ for only a fraction of the typical stack. That is, for $0 < c < 1$, the strategy is given by

$$G(s) = c(1 - s)$$

The spot variance of a fraction hedge is given by:

$$Var\left(D_t\right) = \sigma_1^2 \int_0^t \left(c\left(1-s\right)+s-t\right)^2 ds + \sigma_2^2 \int_0^t \left(c\left(1-s\right)+s-t\right)^2 ds + 2\sigma_1\sigma_2 \int_0^t \left(c\left(1-s\right)+s-t\right)^2 ds \qquad (13)$$

For simplicity of calculation, we set $\sigma_1 = 1$ and $\sigma_2 = .5$ to demonstrate the numerical results.

For the no hedge case, the spot variance becomes the following:

$$Var(D_t) \coloneqq \frac{3t^3}{4}$$

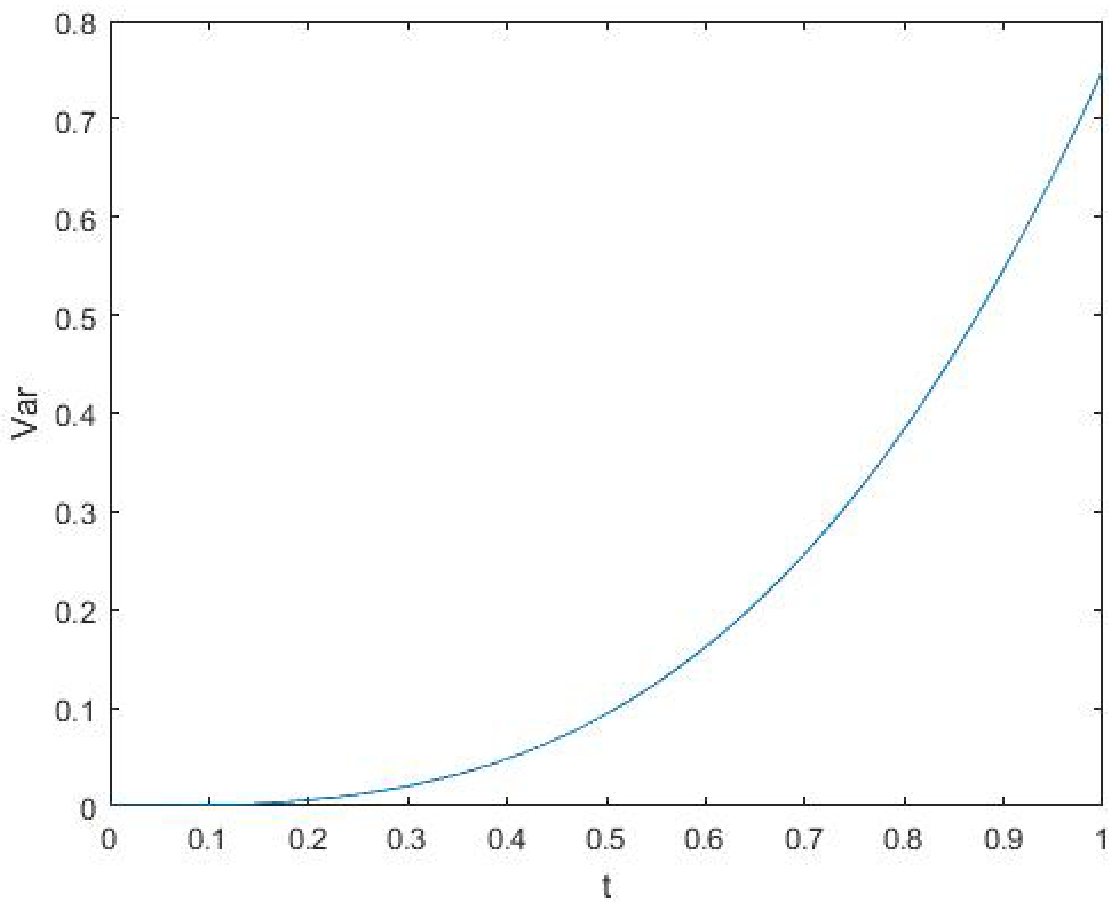

Figure 1: Spot variance of no hedge strategy.

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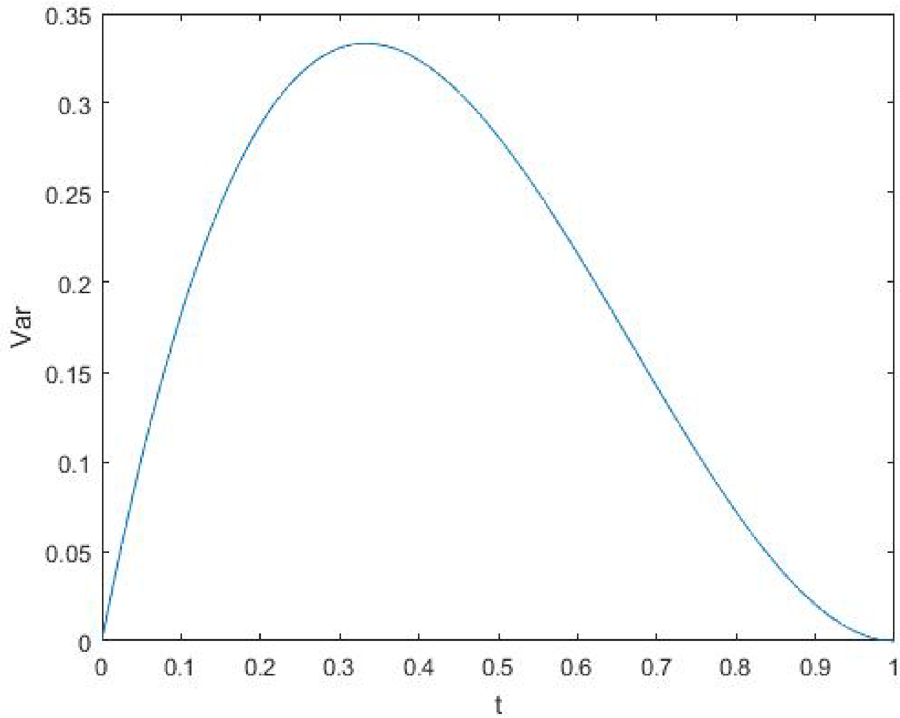

Figure 2: Spot variance of rolling stack strategy

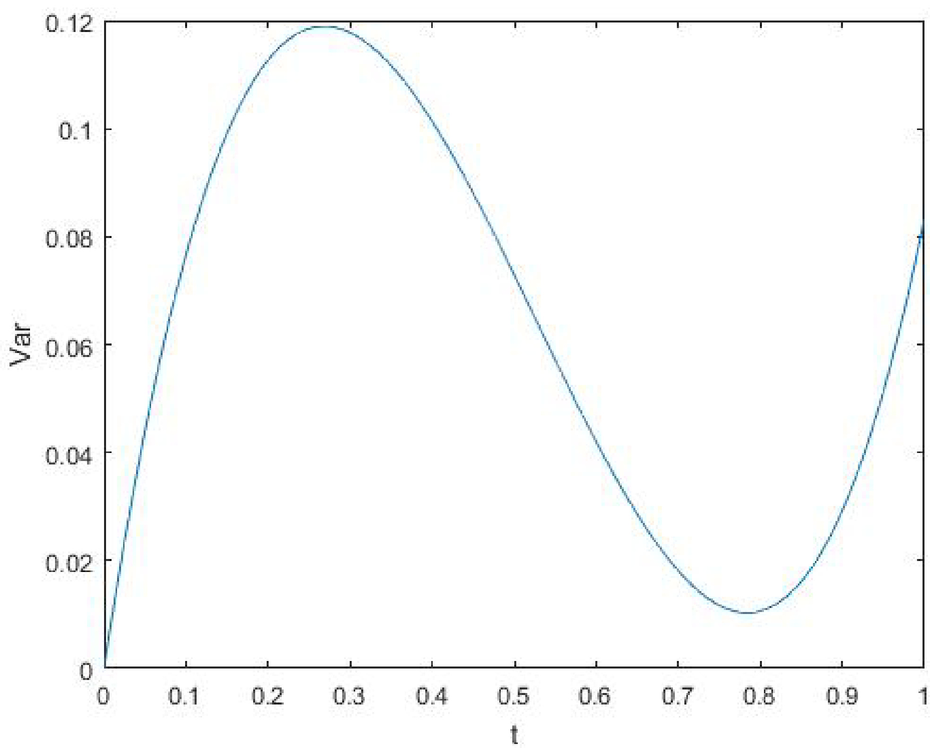

Figure 3: Spot variance of the combination of rolling stack and no hedge.

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For the rolling stack hedge, the spot variance is as follows:

$$Var(D_t) \coloneqq \frac{9t(t-1)^2}{4}$$

For the combining of rolling stack and no hedge, the spot variance becomes:

$$Var(D_t) \coloneqq \frac{t(19t^2-30t+12)}{12}$$

We now explore the so-called optimal fraction strategy. Let the hedging strategies be $G_1(s) = c*(1-s)$ and $G_2(s) = c*(1-s)$. This gives us the following expression for the spot variance:

$$Var\left(D_t\right) \coloneqq h\left(t\right) = \frac{3\left[\left(c-t\right)^3 + c^3\left(t-1\right)^3\right]}{4\left(c-1\right)}$$

We can use standard methods to determine where this function is maximized.

$$\begin{aligned} h'(t) &= \frac{3}{4(c-1)}\left[3(c-t)^2(-1)+3c^3(t-1)^2\right] \\ &= \frac{9}{4(c-1)}\left[(c^3-1)t^2+2c(1-c^2)t+(c^3-c^2)\right] \\ &= \frac{9}{4}\left[(c^2+c+1)t^2-2c(c+1)t+c^2\right] \end{aligned}$$

Let $h'(t) = 0$ to get the critical points $t_{1,2} = \dfrac{c^2+c\pm c^{\frac{3}{2}}}{c^2+c+1}$.

Using second derivative test, $h(t)$ has a relative maximum at $t_2 = \dfrac{c^2+c-c^{\frac{3}{2}}}{c^2+c+1}$.

Clearly, $h(0) = 0$, but the fixed fraction hedge does not result in a zero terminal variance. Therefore, if we are looking for the maximum on $t \in [0, 1]$, we also need to consider

$$h(1) = \frac{3}{4}(c-1)^2 \ .$$

i.e.

$$\max_{0\le t\le 1} h(t) = \max\{h(t_2), h(1)\}.$$

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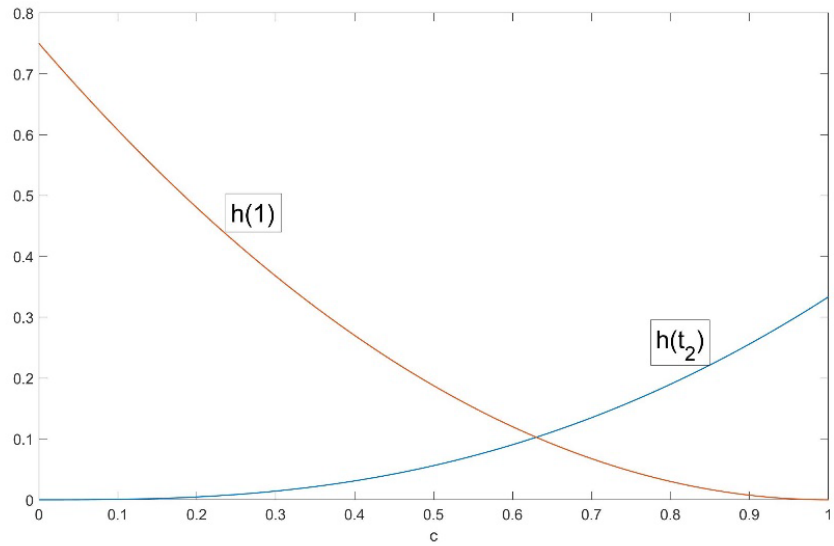
Some straightforward algebra shows that

$$h(t_2) = \frac{3(c^6 + 2c^{\frac{9}{2}} + c^3)}{4(c^2 + c + 1)^2}$$

Consider both $h(t_2)$ and $h(1)$ as functions of c. For $0 < c < 1$, $h(t_2)$ is increasing and $h(1)$ is decreasing. Graphs show as below.



The optimal c that minimizes the overall maximum variance is the one that sets $h(t_2) = h(1)$, i.e. the spot variance at $t = t_2$and $t = 1$ equal, which means, the optimal c stands for the constant that equalizes the running risk with the spot variance at delivery date.

Numerically, we can solve the equation $h(t_2) = h(1)$, to get $c \approx 0.62996$.

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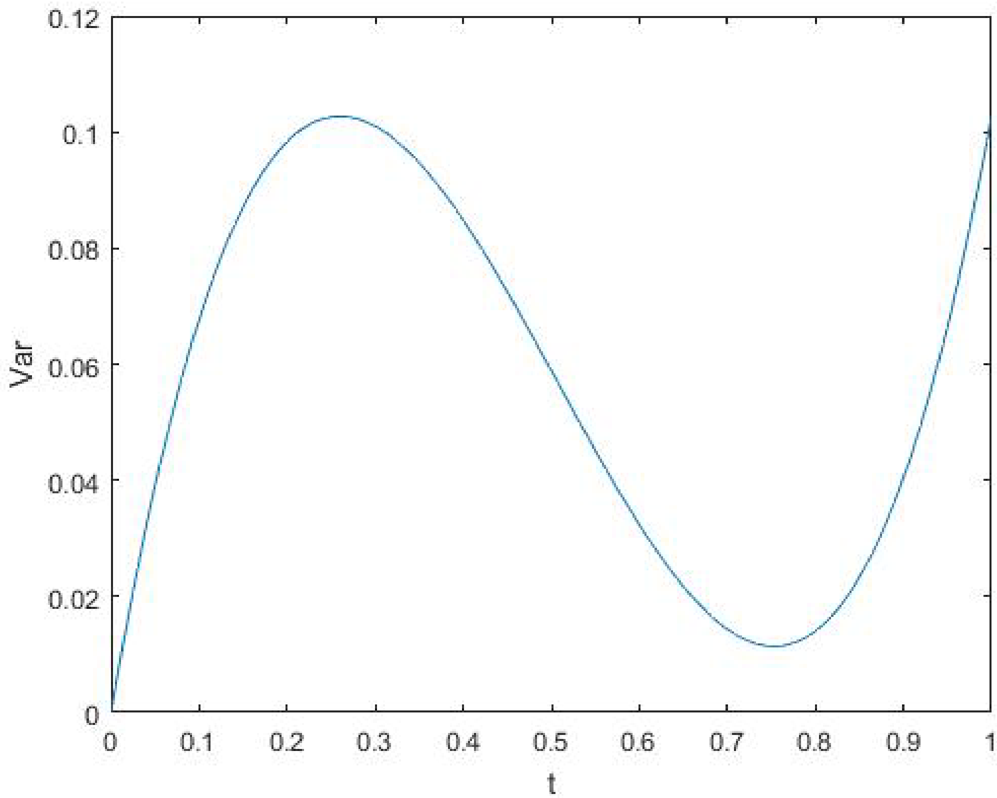

Figure 4. Spot variance of the optimal fraction.

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The following graph provides a comparison of the different hedging strategies.

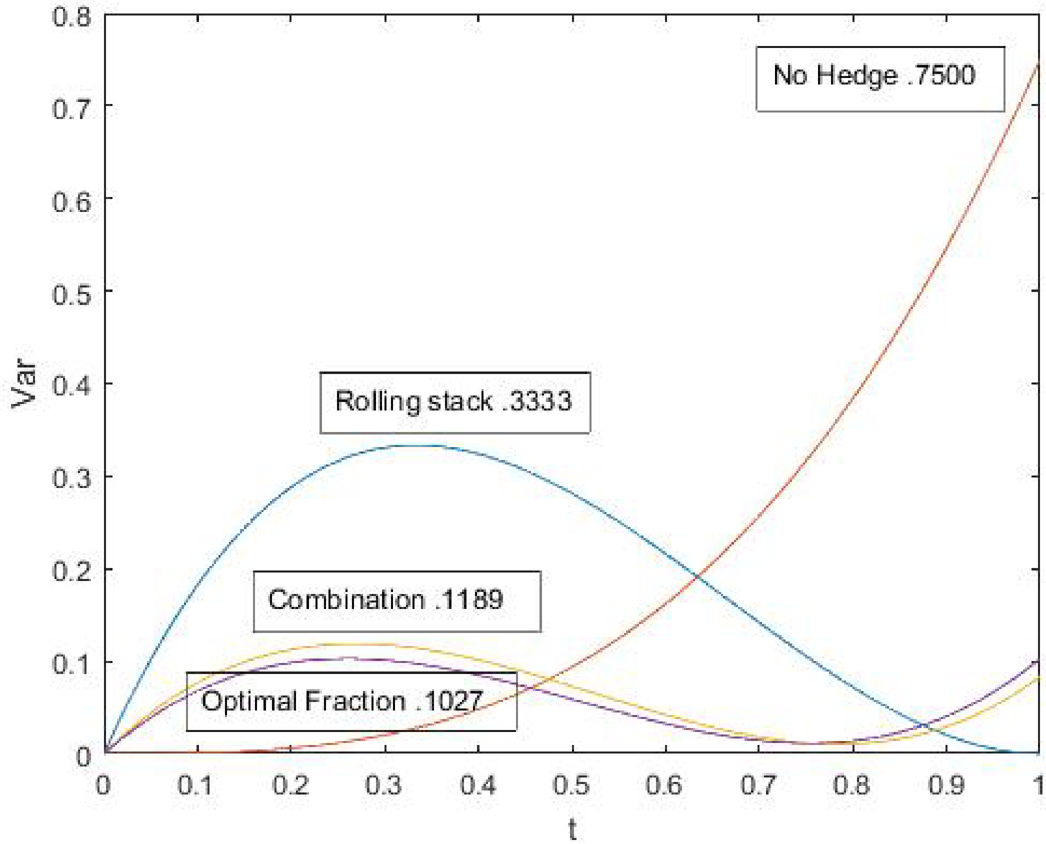

Figure 5. The spot variance of no hedge, rolling stack, combination and optimal fraction.

Clearly, the optimal fraction provides the best outcome among the four strategies considered, where 'best' means having the lowest running risk over the full time interval.

5. AVERAGE RISK

Now we wish to analyze the strategies of minimizing average risk as opposed to minimizing running risk. Let $G_1(s) = k_1(1-s)$ and $G_2(s) = k_2(1-s)$.

$$\begin{aligned} Var\left(D_t\right) &= \sigma_1^2 \int_0^t (k_1\left(1-s\right)+s-t)^2 ds + \sigma_2^2 \int_0^t (k_2\left(1-s\right)+s-t)^2 ds \\ &+2\sigma_1\sigma_2 \int_0^t \left(k_1\left(1-s\right)+s-t\right)\left(k_2\left(1-s\right)+s-t\right) ds \end{aligned} \tag{14}$$

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Again, if we set $\sigma_1 = 1$ and $\sigma_2 = 0.5$,

$$Var(D_t) = \frac{1}{12}(t^3(4k_1^2 + 4k_1k_2 + 6k_1 + k_2^2 + 3k_2 + 9) - t^2(12k_1^2 + 12k_1k_2 + 18k_1 + 3k_2^2 + 9k_2) + t(12k_1^2 + 12k_1k_2 + 3k_2^2))$$

We minimize the area under the curve of $Var(D_t)$ by taking the integral of this variance with respect to t from 0 to 1.

$$Avg(k_1, k_2) = \int_0^1 Var(D_t)dt$$

$$Avg(k_1, k_2) = \frac{k_1^2}{4} + \frac{k_1k_2}{4} - \frac{3k_1}{8} + \frac{k_2^2}{16} - \frac{3k_2}{16} + \frac{3}{16}$$

We find the critical points of $Avg(k_1, k_2)$ by solving the following system of simultaneous equations

$$\begin{cases} \dfrac{\partial Avg(k_1, k_2)}{\partial k_1} = 0 \\ \dfrac{\partial Avg(k_1, k_2)}{\partial k_2} = 0 \end{cases}$$

The (non-unique) optimal values for k_1 and k_2 must satisfy the following condition: $4k_1 + 2k_2 = 3$ and the minimum value of $Avg(k_1, k_2)$ is $\frac{3}{64}$.

Substitute the optimal condition $4k_1 + 2k_2 = 3$ into the $Var(D_t)$ expression above, we can have that the spot variance for the minimum average risk strategy is given by:

$$Var(D_t) = \frac{21}{16}t^3 - \frac{27}{16}t^2 + \frac{9}{16}t$$

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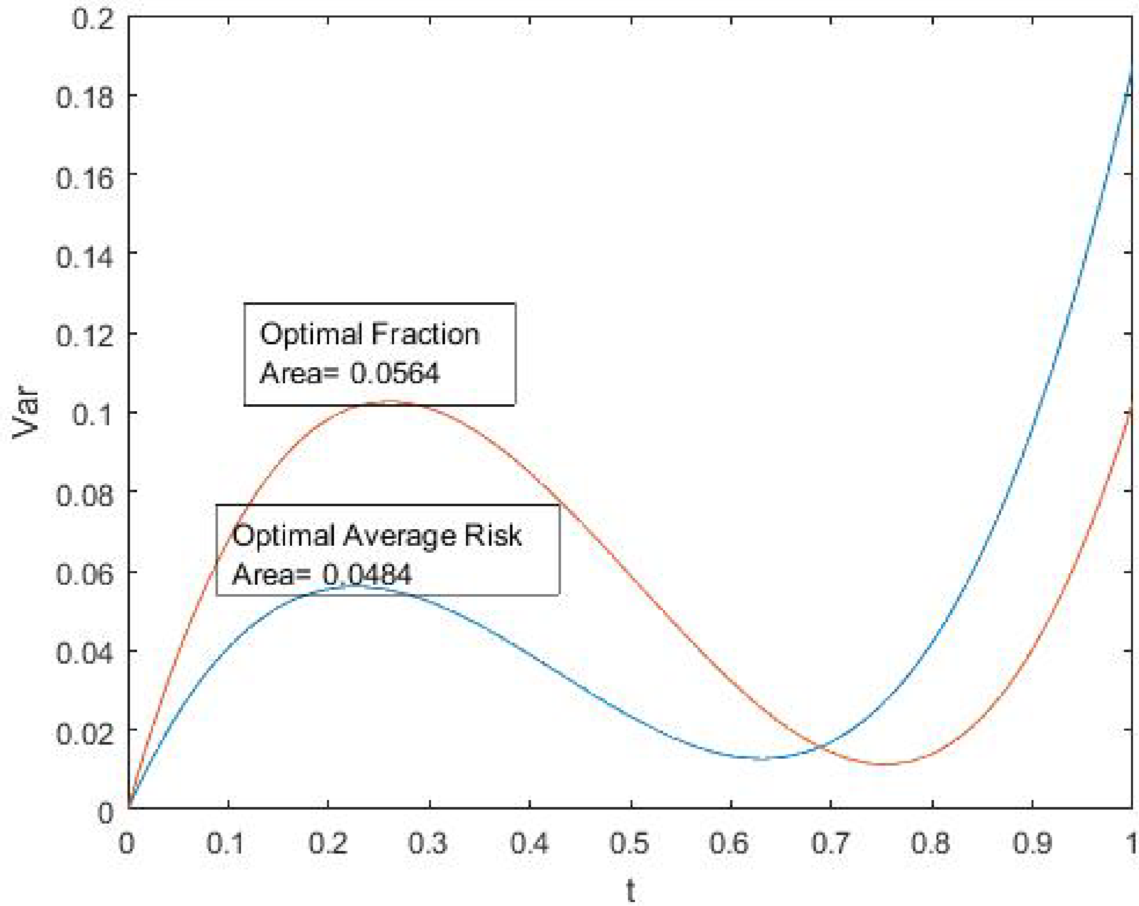

Figure 6. Spot variance of optimal fraction and optimal average risk

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We wish to further explore their relationships. Let's consider the running risk, $R(\sigma_t^2) = \max_{0 \le s \le t} Var(D_s)$.

The running risk of the optimal fraction is given by:

$$R_1(\sigma_t^2) = \begin{cases} \frac{3}{4}(c^2 + c + 1)t^3 - \frac{9}{4}(c^2 + c)t^2 + \frac{3}{4}c^2 t, & 0 \le t \le t_2 \\ \frac{3}{4}c^2 - \frac{3}{2}c + \frac{3}{4}, & t_2 < t \le 1 \end{cases}$$

Where t_2 is the value found previously equal to $((c - 2(c^{3/4})^{1/2} + c^2)/(c^2 + c + 1)$ and c is equal to $\frac{2^{1/3}}{2}$.

The running risk of the optimal average risk strategy is given by:

$$R_2(\sigma_t^2) = \begin{cases} \frac{21}{16}t^3 - \frac{27}{16}t^2 + \frac{9}{16}t, & 0 \le t \le t_2 \\ \frac{259}{4618}, & t_2 < t < t_3 \\ \frac{21}{16}t^3 - \frac{27}{16}t^2 + \frac{9}{16}t, & t_3 \le t \le 1 \end{cases}$$

Where $t_2 \approx .2265$ and $t_3 \approx .8326$. To analyze the risk, one must solve the inequality $R_2(\sigma_t^2) \le R_1(\sigma_t^2)$. We solve it numerically to get $t \le .9089$. Because of this, for about 91% of the exposure, the running risk of the optimal average risk strategy is less than the running risk of the optimal fraction strategy. So, for our hypothetical investor who anticipates a large return near the termination time, the optimal average risk strategy would be a better hedging choice for risk management.

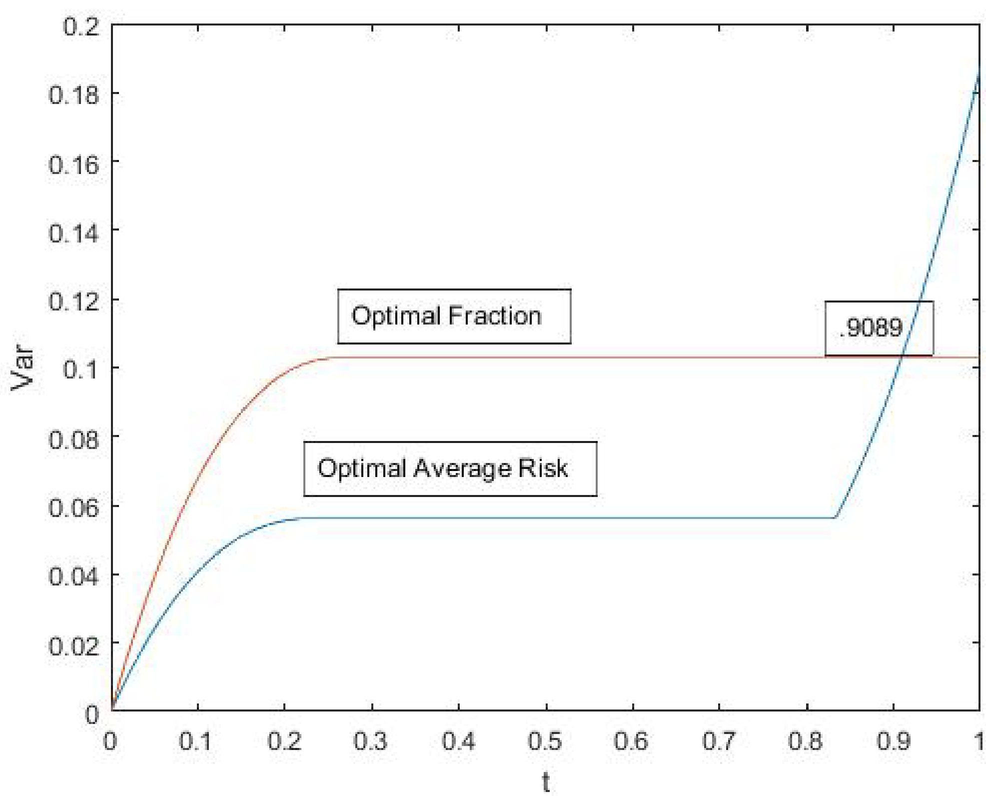

Figure 7. Running risk of the optimal fraction and optimal average risk.

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6. CONCLUDING REMARKS

By extending Glasserman's model to a two-commodity case, we studied shortfall risk in long-term hedging with short-term futures contracts of different strategies, including no hedge, the rolling stack hedge, the combination hedge and the optimal fraction hedge. Additionally, to explore a strategy that minimizes average risk, as discussed in Larcher and Leobacher (2003) and Garcia and Yu (2015), we analyze the hedging strategies in a two-commodity case. We also provide numerical solutions and comparisons of all these hedging strategies. Our study may shed some light on potential strategies for energy companies which are producing both crude oil and natural gas and that use WTI Crude Oil and NYMEX Natural Gas Futures contracts to hedge against the risk of financial losses. The results of our analysis may also be applied to foreign exchange hedging cases since most international companies are exposed to two or more foreign currency risks.

ENDNOTES

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REFERENCES

Culp, C. L., & Miller, M. H. (1994). Hedging a flow of commodity deliveries with futures: lessons from Metallgesellschaft, *Derivatives Quarterly*, 1: 7-15.

Culp, C. L., & Miller, M. H. (1995). Metallgesellschaft and the economics of synthetic storage. *Journal of Applied Corporate Finance, 7*(4), 62-76.

Glasserman, P. (2001). Shortfall risk in long-term hedging with short-term futures contracts. *Option Pricing, Interest Rates and Risk management,* 477-508.

Larcher, G., & Leobacher, G. (2003). An optimal strategy for hedging with short-term futures contracts. *Mathematical Finance, 13*(2), 331-344.

Leobacher, G. (2008). On a class of optimization problems emerging when hedging with short-term futures contracts, *Mathematical Methods of Operations Research*, 67: 65-90.

Mello, A.S. and Parsons, J.E. (1995). Maturity structure of a hedge matters: lessons from the Metallgesellschaft debacle, *Applied Corporate Finance*, 8: 106-120

Wu, Z., Yu, C., & Zheng, X. (2011). Managing risk with short-term futures contracts. *SIAM Journal on Financial Mathematics, 2*(1), 715-726.

Garcia, J., & Yu, C. (2015). Minimizing Average Risk with Short-Term Futures Hedging. *Alabama Journal of Mathematics, 39,* 1-5.

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Appendix A: Brownian motion and Ito's Isometry

A stochastic process $\{B_t\}_{t\geq 0}$ is said to be a standard **Brownian motion** if

1) $B_0 = 0$;
2) $\{B_t\}_{t\geq 0}$ has stationary independent increments;
3) for every $t > 0$, B_t is normally distributed with mean 0 and variance t.

Denote by $\mathcal{F}_t$ the σ −algebra generated by the random variable $\{B_s\}_{0\leq s\leq t}$ and by $\mathcal{F}$ the σ −algebra generated by $\{B_s\}_{s\geq 0}$. A process $f(t,\omega)$ is called $\mathcal{F}_t$ adapted if for each $t \geq 0$ the function $\omega \to g(t,\omega)$ is $\mathcal{F}_t$ measurable.

Ito's Isometry Let $f(t,\omega)$ be a $\mathcal{F}_t$ adapted process. Then

$$E\left[\left(\int_S^T f(t,\omega)dB_t\right)^2\right] = E\left[\int_S^T f^2(t,\omega)dt\right]$$

People may read a standard stochastic calculus book for more details on these topics.

Appendix B: Variance of a hedged cash flow

In this appendix, we give background and mathematical proofs related to variance of a hedged cash flow. Some good references for this section are Glasserman (2001), Larcher and Leobacher (2003) and Leobacher (2008).

A firm has a commitment to deliver a fixed quantity q of a commodity at a forward price a_t at time t in the interval $[0,1]$. By doing so the firm is taking the risk of the underlying commodities' future price movements. The firm will have to pay the market price for the underlying commodities to deliver the contract which might result in loss of cash if the spot price of the underlying commodity rises abruptly. To reduce the risk of losses due to possible price fluctuations, the firm might enter into a sequence of short-dated futures contracts to protect itself from the effects of large price fluctuations. Assume that the market price of the underlying commodities is given by a simple stochastic differential equation, i.e.

$$dS_t = \mu dt + \sigma dB_t$$

where B_t is Brownian Motion process on $[0,T]$, μ and σ are constants, $\sigma > 0$. We further assume that the interest rate $r = 0$, $T = 1$ and $q = 1$.

The unhedged cash flow from this contract is

$$C_t = \int_0^t a_s - S_s ds$$

with an exposure of

$$C_t - E[C_t] = \int_0^t (E(S_s) - S_s)ds = -\sigma\int_0^t B_s ds = -\sigma\int_0^t (t-s)dB_s$$

Consider now at time t a short term future with maturity $t+\delta$ and futures price $F_{t,t+\delta}$. The payoff of such a contract is

$$S_{t+\delta} - F_{t,t+\delta}$$

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If we write $F_{t,t+\delta} = S_t + b_{t,t+\delta}\delta$, then we get for the payoff

$$S_{t+\delta} - S_t - b_{t,t+\delta}\delta$$

where $b_{t,t+\delta}\delta$ is the basis of the future, i.e. the deviation from the "nature" price S_t.

The payoff from a hedging strategy holding $G_{n\delta}$ futures at time $n\delta$ is therefore

$$H_{k\delta} := \sum_{n=0}^{k-1} G_{n\delta}(S_{t+\delta} - S_t) - \sum_{n=0}^{k-1} G_{n\delta} b_{t,t+\delta}\delta$$

Letting $\delta \to 0$ gives the continuous form

$$H_t = \int_0^t G_s dS_s - \int_0^t G_s b_s ds$$

where we assume that $b_t := lim_{\delta\to 0} b_{t,t+\delta}$ exists and is regular enough to guarantee existence of the integral.

Since $dS_t = \mu dt + \delta dB_t$, this means that

$$H_t = \int_0^t G_s \sigma dB_s + \int_0^t G_s(\mu - b_s)ds$$

Note that if $G_s(\mu - b_s)$ is deterministic for almost all s, the cash flow H from a hedging strategy G satisfies

$$H_t - E[H_t] = \int_0^t G_s \sigma dB_s$$

The hedged cumulative cash flow from this contract is $C_t + H_t$. Let $Var(C_t + H_t)$ be variance of this cash flow.

$$C_t + H_t - E[C_t + H_t] = \sigma \int_0^t (s - t + G_s) dB_s$$

By Ito's isometry we have

$$Var[C_t + H_t] = E\left[\left(\sigma \int_0^t (s - t + G_s)dB_s\right)^2\right] = \sigma^2 \int_0^t E[(s - t + G_s)^2]ds$$

From Jensen's inequality it follows that

$$\int_0^t E[(s - t + G_s)^2]ds \geq \int_0^t (E[s - t + G_s])^2 ds$$

with equality if and only if G_s is the deterministic for almost all $s \in [0,1]$. So we may restricts our search to deterministic strategies.

If we write $g(s) := s + G_s$, then $Var(C_t + H_t) = \sigma^2 \int_0^t (t - g(s))^2 ds$.

For two-commodity case as introduced in the paper, clearly

$$C_{1t} + H_{1t} - E\left(C_{1t} + H_{1t}\right) = \int_0^t \sigma_1 \left(g_1(s) - t\right) dB_s$$

$$C_{2t} + H_{2t} - E\left(C_{2t} + H_{2t}\right) = \int_0^t \sigma_2 \left(g_2(s) - t\right) dB_s$$

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$$Var(C_{1t} + H_{1t}) = \sigma_1^2 \int_0^t (g_1(s) - t)^2 ds$$

$$Var(C_{2t} + H_{2t}) = \sigma_2^2 \int_0^t (g_2(s) - t)^2 ds$$

Let $D_t = C_{1t} + H_{1t} + C_{2t} + H_{2t}$. Then

$$D_t - E[D_t] = \int_0^t \sigma_1(g_1(s) - t) + \sigma_2(g_2(s) - t)\, dB_s$$

Therefore,

$$Var[D_t] = \int_0^t [\sigma_1(g_1(s) - t) + \sigma_2(g_2(s) - t)]^2 ds$$

$$= \sigma_1^2 \int_0^t (g_1(s) - t)^2 ds + \sigma_2^2 \int_0^t (g_2(s) - t)^2 ds + 2\sigma_1\sigma_2 \int_0^t (g_1(s) - t)(g_2(s) - t) ds$$

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The Determinants of Draft Position for NBA Prospects

Brent A. Evans and Joshua D. Pitts*

ABSTRACT

Using NBA draft data from the 2006-2015 NBA seasons, the authors estimate models predicting draft selection, finding that points, assists, and blocks per-40-minutes of play during a player's final college season are all correlated with being selected earlier in the NBA draft among the entire player pool in the dataset. However, secondary findings indicate that not all player characteristics are valued evenly among different player-types. Taken in unison, findings suggest that the selection of players in the NBA draft can indeed be predicted using college statistics and other control variables, but models lumping all players may provide misleading results.

Keywords: NBA, recruiting, basketball, NBA draft, sports economics

I. Introduction

One potential avenue for success for an NBA franchise is its ability to select the best available players in the NBA draft. This is clearly evident when considering the top teams in the NBA. For example, the winningest team over the last few seasons, the Golden State Warriors, have managed to select players such as Steph Curry (2009), Klay Thompson (2011), and Draymond Green (2012), whose productivity has clearly outpaced the typical production of players drafted 6th, 11th, and 35th overall, respectively. While coaching, management, and the signing of free agents all play critical roles, these factors are often guided by circumstances outside of a general manager's (GM) control—for example, NBA GMs may have more difficulty attracting talent in smaller markets or in cities with colder climates—whereas every NBA team has the unique opportunity to select any available player in the NBA draft. While the draft helps shape the entire NBA landscape, research on the subject is relatively scarce.

In this paper, we analyze the determinants of draft-order during the 2006 to 2015 NBA drafts. These years were chosen because they represent the first 10 seasons following the 2006 rule change in which players were required to wait one year following high school graduation before entering the NBA draft. In order to gain a thorough understanding of the determinants of draft selection, we first estimate a model for all players. Then, the data are broken down by a player's position and his number of collegiate seasons. Considering a player's performance per-40-minutes of play during his final college season, we find that points, assists, blocks, and two-point percentage are all correlated with being selected earlier in the draft. However, per-40-minute rebounds and turnovers, along with free-throw and three-point percentage, do not significantly correlate with draft position. Thus it appears that certain abilities are more highly valued than others. We also find that prospects from winning teams and those playing for power conference teams tend to be drafted earlier than otherwise similar players. Not surprisingly, younger players, who have more potential for additional development, are selected earlier in the draft. Height is also correlated with an earlier draft-selection, while a player's body-mass-index (BMI) is not a significant determinant. These characteristics are analyzed in depth in the latter sections of this paper and the results show that the importance of these characteristics differs by player experience and positon.

II. Literature Review

Prior Research on the Determinants of Draft Position

A smattering of researchers have made efforts to determine the characteristics that inform a player's draft position. The most well-rounded analysis was composed by Berri, Brook, and Fenn [2011], who analyzed draft determinants between the years of 1995 and 2009, inclusive. Controlling for the draft year and conference, among other variables, the researchers found that total points, assists, blocks, and two-point field goal percentage during a player's final collegiate season all correlate with improved draft position. While this study was used as a model when conducting the current research, there is a potential flaw that may bias regression results: The authors failed to control for the number of collegiate seasons for which each player competed. Elite recruits will have the option to enter the draft after only one college season; these same players, despite being elite prospects, may not receive quite as much playing time or statistic-generating opportunities (i.e., the players may not handle the ball as frequently as upper-classmen) as otherwise-identical players. Indeed, our dataset shows clear and systematic differences in statistical output among four-year players and players that entered the NBA draft as underclassmen. For example, four-year players played more collegiate minutes and scored more points per minute than "one-and-done" players. However, these same four-year players were drafted, on average, *much* later than one-and-done players. By failing to control for collegiate seasons, the analysis provided by Berri, Brook and Fenn [2011] may lead to a biased result for control variables, such as points. Due to this concern, and considering the fact that the Berri, Brook, and Fenn [2011] study uses data that are becoming increasingly outdated, a new study is warranted.

While the Berri, Brook, and Fenn [2011] study stands as the most important piece of literature for purposes of the current research, there are additional findings to consider from other papers. In a meta-analysis, Berri [2005] found that points scored in college was the most important factor in determining a player's NBA salary, and thus, reason would suggest would also be an important factor in determining draft position. Among the prior research scrutinized, Berri also found that rebounds, blocked shots, and assists were significant in at least half of the models that employed these variables, while variables such as field goal percentage, free-throw percentage, steals, personal fouls, and turnovers were generally found to be insignificant. Continuing the theme of points-scoring as a major factor of draft position, Coates and Oguntimein [2010] found that collegiate points were a major determinant of a player's draft position for players drafted in 1985, 1986, and 1987, but their research found little connection between a player's collegiate points-scoring and his NBA scoring proficiency. In other words, collegiate points impacted draft ordering and perceived ability, but actual NBA points-scoring was not a function of collegiate points.

One surprising result is detailed by Ichniowski and Preston [2012]. They found that performance in the NCAA tournament is disproportionately valued in the NBA draft as compared to NCAA regular season performance. For example, an NCAA tournament victory in which a player scores 4 or more additional points relative to the regular season was found to correlate to a 4.7 slot improvement in the NBA draft. They also show that this is not a mistake among NBA executives--these players are actually more likely to become NBA superstars than their counterparts.

Groothuis, Hill, and Perri [2007] found that early-entrants play fewer minutes than four-year prospects and that these earlier entrants tend to improve more quickly in the NBA. Likewise, Rodenberg and Kim [2011] showed that younger NBA draftees typically have better NBA careers than older players with more college experience. Additionally, the authors found little to no significance for race or being born internationally in their models estimating NBA success.

The Economic Significance of High-Quality Prospects

While NBA fans will quickly attest that attaining high draft picks is of great importance for NBA franchises, academic literature finds mixed evidence. For example, Motomura et al. [2016] showed that teams possessing a high percentage of early, first-round draft picks tend to be average to below-average teams. The authors suggest that good franchises with strong leadership tend to build the most successful teams, regardless of the number of early draft picks. On the contrary, Berri and Schmidt [2010] found that draft order does positively correlate with future on-court success, but the correlation is very weak; only about 5% of the variation among NBA teams' wins can be explained by the order of prior draft picks.

While the statistical connection between attaining top draft picks and a team's long-run success is unclear, NBA executives are undeniably interested in attaining top draft picks and are willing to sacrifice to do so. This is evidenced, firstly, by recent NBA trades in which NBA executives and GMs have willingly traded productive and seasoned players in order to have a chance at landing a top prospect. There are countless examples of such trades; for instance, in 2011, the San Antonio Spurs traded a major contributor—George Hill—to the Indiana Pacers in order to draft future superstar Kawhi Leonard with the 15th selection. Secondly, because NBA draft picks are generally awarded to the NBA team's with the worst records, there are incentives for NBA teams to "tank" (i.e., intentionally lose in an effort to increase the odds of attaining an earlier draft pick). Not surprisingly, researchers have attempted to determine if NBA teams are indeed taking advantage of this incentive. Taylor and Trogdon [2002] showed that, following implementation of the NBA's current lottery system, teams that were eliminated from playoff contention were twice as likely to lose games as teams still in contention, even after controlling for team quality. Soebbing and Humphreys [2010] showed that wagering behavior suggests that gamblers anticipate tanking among NBA teams even if the evidence of NBA teams actually intentionally losing games is unclear. While this discussion is not especially pertinent to the current research, it highlights just how important the NBA draft has become. NBA teams are literally willing to sacrifice wins in order for a *chance* to attain an earlier pick.

Because NBA franchises are willing to trade solid contributors and cash for draft picks and due to the prevalence of tanking, it is clear that NBA executives view top draft picks as valuable assets. This is likely due to the fact that top draft picks are very talented and have the potential to be NBA stars. But there is also a cost-based incentive to filling a roster with young players. Krautmann, von Allmen, and Berri [2009] found that NBA players under rookie contracts tend to be underpaid relative to their peers due to the fact that rookies are selected in the draft and thus cannot "shop-around" for a higher salary as veteran free agents may choose to do. This increases the per-dollar value of attaining recent draft picks (by drafting or via trade).[i]

While the value of top picks is debated in the sports economics literature, NBA franchises are clearly highly motivated by them. Because studies on the NBA draft are sparse and becoming increasingly outdated, a new study on the determinants of draft position is warranted.

III. Data and Methodology

In this paper, we attempt to analyze the determinants of draft-selection in the NBA draft and then consider the performance of NBA players' post-draft, using ordinary least squares (OLS). We use a full decade of data; included in the dataset are players that were drafted from 2006 to 2015. This timeframe was chosen because rule changes necessitated that prospects must wait one year following high school before entering the NBA draft. Thus, the dataset includes the first ten drafts that have occurred since this rule change. Because there are 30 NBA teams and two rounds of draft each year, there are a total of 60 players drafted yearly and 600 draft picks over the entirety of our sample. However, a sizable proportion of these players did not play college basketball in the U.S.—most of these players are internationals that played overseas for the entirety of their lives prior to the NBA draft, while a smaller group of these players are Americans that decided to spend one year playing professional basketball internationally prior to the NBA draft instead of participating at the college level. After dropping these players, we are left with a dataset of 470 players, all of whom played at least one year of college basketball in the U.S. Data were primarily collected from Realgm.com and basketball-reference.com, two websites that provide vital information on college and professional basketball players.

Data for all models are provided in Table 1 and Table 2. *DRAFTPOSITION* represents a player's draft position after deleting players that did not play college basketball in the U.S. For example, Lamarcus Aldridge was the 2nd overall pick of the 2006 NBA draft, following international Andrea Bargnani. Because Bargnani did not play college basketball in North America, Lamarcus Aldridge is labelled as having a draft position of one in our dataset. By doing so, we are able to eliminate potential bias caused by a very strong (or very weak) international draft class. As a result, the *DRAFTPOSITION* variable provides an ordinal ranking system of the prospects that played college basketball; a *DRAFTPOSITION* of 35 indicates that a player was the 35th overall pick for a given year among those that played college basketball in the U.S.

POINTS, *ASSISTS*, *REBOUNDS*, *STEALS*, *BLOCKS*, and *TURNOVERS* represent the frequency of each of these variables for each player in his final collegiate year, per-40-minutes of play. For example, an average player in his final collegiate season scored 19.7 points per-40-minutes prior to being selected in the NBA draft. In Tables 1 and 2, each variable is provided unaltered in order to make comparisons; however, in the primary regression, these basketball performance variables are standardized by player position. Therefore, each variable has a mean of zero and a standard deviation of one. [ii] By doing so, we are able to control for the possibility that the importance of these variable are different for each position; for example, assists could be very important for guards, but of little importance of centers. The variables, *2PT%*, *3PT%*, and *FT%* indicate players' two-point, three-point, and free throw percentages during his last college season, respectively, standardized by position. *POWERCONF* is a dummy variable indicating whether a player participated in one of the so-called power conferences--ACC, BIG 10, BIG 12, BIG EAST, PAC 12, and SEC. Strong prospects may be able to improve their team's performance. For this reason, we include *WIN%*, which is the win percentage during a prospect's final collegiate season. Likewise, coaching could also improve a player's draft stock. *COACHWIN%* indicates the career winning percentage for each player's collegiate coach and *COACHWINEXP* is the total number of years that coach has been a head coach at an *NCAA D1* program.

One important factor to consider is a player's number of collegiate seasons. The NBA requires that draft prospects must wait one year after high school to be eligible for the NBA draft and the vast majority of prospects choose to use this year playing collegiately. However, unlike football or baseball, players do not face any additional restrictions; players may choose to enter the NBA draft at any point after this one-year window. For this reason, many elite prospects declare for the draft after their freshman years while border-line prospects usually play a full four seasons. This is not always the case; there are certainly instances where elite prospects have played four years in college (e.g., Damian Lillard and J.J. Redick were selected 6th overall and have had strong NBA careers) and cases where a player entered the draft after one college season and had a less than stellar NBA career. In fact, thirty early entrants went undrafted during the 2016 NBA draft. Nonetheless, elite prospects are often easy to identify, even at an early age. For this reason, NBA executives have been quick to select early-entry players, and indeed early-entrants tend to be more successful and exhibit greater improvement during their NBA careers, as explained in Groothuis, Hill, and Perri [2007]. *ONEYEAR*, *TWOYEAR*, *THREEYEAR*, and *FOURYEAR* indicate the number of total seasons that a player participated in college basketball. In our dataset, only 36.6% of players spent a full four years in college. We also include *AGE* since NBA executive may prefer to draft younger players who have more time to develop and perhaps have greater upside as a result. In Table 1, we divide the summary statistics into three categories—all players, early entrants, and four-year players. While these statistics show that these players exhibit similar performance numbers (e.g., *POINTS*), it is important to note that these statistics are for a player's final collegiate season and it is not surprising that four-year players exhibit comparable, or even stronger numbers, since they are competing as seasoned collegiate veterans. However, the *DRAFTPOSITION* variable clearly indicates that these two groups are truly disparate—among those that play college basketball, an average early entrant (that is drafted at all) is drafted around the 20th slot while four-year players are drafted around the 32nd slot. Not surprisingly, early entrants are also younger—nearly two-years younger than four-year players, on average.

As is often said in sports, height can't be taught. We include the variable *HEIGHT* (measured in total inches) under the assumption that NBA executives may prefer to select taller players. Even after controlling for other variables, taller players may have a better chance to develop into NBA-caliber players. Likewise, we include body mass index since a players' overall size could also be a characteristic that executives consider.

Finally, we include a dummy variable for each position for which a player is listed on Realgm.com. As indicated by the summary statistics, shooting guards are drafted most frequently, while centers are drafted the least. Because draft considerations may be different among positions, we include dummy variables for position in the primary model. In addition, we will estimate regressions for players of each position in addition to the primary model that includes all players. Summary statistics by position are provided in Table 2. Not surprisingly, there are substantial differences among players of each position for many variables—guards are more likely to earn assists and are more proficient at three-point shooting and free-throws, while forwards and centers collect more rebounds, block more shots, and are more effective in two-point shooting. Interestingly, guards are statistically less likely to attend a power conference program. Perhaps taller players are more likely to be recruited by top programs while the shortest prospects (traditionally point guards) sometimes fly under the radar.

In order to fully consider the determinants of draft position, we estimate eight OLS models. The primary model includes all players in the dataset, while additional models are broken down by collegiate seasons played (early entrants and four-year players) and by player position (PG, SG, SF, PF, and C). In the primary model, a player's draft position is regressed on a host of independent variables that are described above. The primary model is identified as:

$$
\begin{aligned}
DRAFTPOSITION_n = \beta_0 &+ \alpha_n COLLEGESTATS + \beta_1 WINPCT + \beta_2 POWERCONFERENCE \\
&+ \beta_3 COACHWIN\% + \beta_4 COACHEXP \\
&+ \beta_5 TWOYEAR + \beta_6 THREEYEAR + \beta_7 FOURYEAR \\
&+ \beta_8 AGE + \beta_9 HEIGHT + \beta_{10} BMI \\
&+ \beta_{11} SG + \beta_{12} SF + \beta_{13} PF + \beta_{14} C \\
&+ \alpha_j YEAR + \varepsilon_{it}
\end{aligned}
$$

where *COLLEGESTATS* is a vector of basketball specific variables from a prospect's final collegiate season (*POINTS*, *ASSISTS*, etc.), *YEAR* is a series of dummy variables representing each draft year in the sample, and all other variables are as described previously. This model generally follows the approach set forth by Berri, Brook, and Fenn [2011], but include the key addition of the dummy variables accounting for a player's collegiate experience (*TWOYEAR, THREEYEAR,* and *FOURYEAR)*.

IV. Results

First, we estimate a model predicting draft selection among all players in our sample, as provided in Table 3. Generally, the results align with the findings of prior literature and conventional wisdom about the NBA draft and player potential. We find that points-per-40-minutes scored during a player's final collegiate season is indeed a major determinant of draft position. A one standard deviation increase in points-per-minute is correlated with an improvement in draft position by about four slots. We also find significance for assists and blocks, in which a one standard deviation increase in these variables is associated with 1.5 and 2 draft-slot improvements, respectively, and borderline-significance for steals. Surprisingly, rebounds and turnovers are not found to significantly correlate with draft position Considering the results of these per-40-minute variables in aggregate, it is clear that points-scoring is one of the most important factors for a potential NBA draftee. This result echoes the findings of Berri, Brook, and Fenn [2011], who argue that total points is the most important factor determining draft selection.[iii]

Among the shooting percentage variables (*2PT%, 3PT%,* and *FT%),* only *2PT%* is significant. The coefficient indicates that a one percentage point improvement in a player's two point shooting percentage leads to an improvement of about 1.5 draft slots. Since the standard deviation for *2PT%* is nearly five percentage points, the effect of two-point efficiency on draft position appears to be rather strong. Considering the increased emphasis on three point shooting in recent years, NBA enthusiasts may find it surprising that three point shooting percentage is not found to be a significant determinant of a player's draft selection. However, this result was also reported by Berri, Brook, and Fenn [2011]; thus, it appears that this is not merely a statistical aberration.

Our results indicate that players from winning teams tend to earn better draft outcomes, compared to otherwise similar players on less successful teams. A ten percentage point increase in a college's winning percentage during a player's final collegiate season is associated with a two slot improvement in the draft. For the two coaching variables, we find a significant result for coaching experience, but not for winning percentage. Each additional year of head-coaching experience for a prospect's coach is associated with a small, but significant, improvement in draft selection, which suggests that prospects may improve their odds of attaining an improved draft selection by joining a team with a veteran coach.

As expected, the number of collegiate seasons in which a prospect plays basketball is correlated with draft selection. Compared to the baseline case of a one-and-done player, two-year, three-year, and four-year college players can expect to be drafted in lower rounds. This is not surprising, because the most talented and sought-after players often choose to enter the draft after one year because they know that an early draft selection is probable, whereas more marginal NBA prospects tend to spend more years in college hoping to hone their skills and improve their status as a potential NBA draftee.[iv] Even after controlling for collegiate years, younger players are still drafted earlier than otherwise similar prospects—an additional year of age is associated with being selected 3.6 slots higher. Considering these results in aggregate, it is clear that the number of collegiate years and a player's age are both independently important and the statistical magnitude of these variables are all very strong.[v]

Not surprisingly, height is a determinant of draft selection. This is especially interesting considering the *HEIGHT* variable is standardized by position. Thus, even after accounting for a player's position, a one standard deviation increase in height (equivalent to about 1.5 inches) is associated with a 1.4 draft-slot improvement. Unlike other important variables such as a player's scoring ability, height cannot be improved by practice or coaching. Thus, it is not surprising that NBA owners and managers would place an emphasis on this characteristic. Interestingly, we find no significance for the BMI variable; it seems reasonable that NBA executives would care about a player's weight, but perhaps this is considered only a minor issue since weight, unlike height, can be increased or decreased as needed through training and diet. Finally, the four position variables indicate that there are minor differences among the positions. Being listed as a small forward is an advantage for a player's draft selection, relative to being a PG, SG, or PF.

Early-entrants vs. Four-year players

In addition to the primary model, we estimate a model containing only early-entrants (players that enter the NBA draft after three or fewer years of college play) and a model with only four-year players. Results for this model are also available in Table 3. It is quickly apparent that the determinants of draft position differ between these two groups. While the coefficient for *POINTS* is similar in the two tables, the rest of the results greatly differ. We find significant effects for *ASSISTS*, *BLOCKS*, and *2PT%* among early-entrants, but none of these variables are significant for four-year players. On the contrary, *REBOUNDS* and *3PT%* are significant for four-year players, but not for early-entrants. For both early-entrants and four-year players, participating on a team with a higher winning percentage is associated with an improvement in draft-selection, but playing in a power conference is only found to be significant among early-entrants.

AGE is found to be significant for early entrants—a one-year increase in age is associated with a draft-slot that is four slots worse than otherwise similar players. However, AGE is not significant for four-year players, perhaps because players have already realized much of their potential by their senior years anyway. For example, consider two very similar players aged 18 and 20 years. NBA executives may prefer to draft the younger player since the 18-year-old may have more room for improvement (and may even add an inch or two of height). However, for two senior players aged 22 and 24, NBA executives may draft such players based on their ability to contribute immediately and are thus less focused on potential. An emphasis on potential may also explain the model discrepancies for the *HEIGHT* variable, which is found to be highly significant for early-entrants and clearly insignificant for four-year players. For example, NBA executives may choose to take a chance on a tall, unpolished, sophomore center, since this player may have room to improve. While height certainly has the chance to improve play for seniors, the advantage of being taller may already be absorbed in the player's senior-year stats and is thus not independently significant.

It is difficult to ascertain any clear-cut takeaways from the results of these two models. Part of the disparity may result from a relatively small sample for four-year players; however, the fact that some variables are significant for four-year players but are insignificant among early-entrants does lend additional credence to the general finding: The determinants of draft order differ between early-entrants and four-year players. This could result from the fact that NBA executives have less information for early entrants than they do for four-year players, simply because four-year players have played more collegiate games. Executives may be able to better capture a four-year players true value, including intangible factors like leadership and determination, while the lack of information for early-entrants may cause executives to fall back on measureables, such as scoring and rebounding proficiency. That being said, all variables exhibit the same "sign" in both regressions, indicating that it is perhaps the magnitude of these effects that varies, rather than the directionality.

Estimating the Model by Player Position

Without question, the characteristics and skills that players possess will be valued differently by position. For example, NBA executives may consider rebounds to be most important for centers and least important for point guards. We controlled for this possibility in prior regressions by standardizing these variables by position. While this control should "fix" this potential problem, it does not allow for any comparison among positions. In order to investigate differences among players by positions, we estimate five unique regressions, one for each position (point guards [PG], shooting guards [SG], small forwards [SF], power forwards [PF], and centers [C]). Because these regressions include players for specific positions, there is no need to standardize the performance variables by position as had been done in prior regressions. As a result, the performance variables (*POINTS*, *ASSISTS*, *REBOUNDS*, *STEALS*, *BLOCKS*, *TURNOVERS*, *2PT%, 3PT%,* and *FT%)* in these position-specific regressions represent totals per-40-minutes of play. Likewise, *HEIGHT* and *BMI* are not standardized in these alternate regressions. As a result of these changes, the interpretation of results is slightly different than in prior regressions. Results are presented in Table 4.

Consistent with the findings of prior research (e.g., Berri, Brook, and Fenn [2011] & Berri [2005]) and alternate regressions in the current research, scoring per-40-minutes is significant in all five regressions, once again indicating the focus of NBA executives on scoring proficiency. For example, scoring one more point per-40-minutes of play is associated with a one-slot improvement for draft position among point guards. Aside from the convincing results for *POINTS*, there is little consensus from position to position in regards to variable significance, which may in part be a result of the small sample size. However, many of the results fall in line with conventional wisdom. For example, *ASSISTS* is found to be significant for point guards; however, it is a bit surprising that *ASSISTS* is also significant for centers. In both cases, the coefficients are rather large. For centers, one extra assist per-40-minutes is associated with an improvement of more than five draft slots. The only other variables that are significant for point guards are AGE and body-mass-index (*BMI*). Among all regressions, *BMI* is only significant in the point guard regression, indicating that thinner point guards tend to be drafter earlier than otherwise similar players, perhaps because agility is held at such a premium for point guards.

One might expect to find similar results for shooting guards and small forwards, since these positions are virtually interchangeable on the offensive end for many college and NBA programs. But, the results are actually highly differentiated. For shooting guards, *BLOCKS* and *STEALS* are found to both be significant (although the significance is marginal for the latter). An additional block per-40-minutes is correlated with an improvement in draft position of more than 11 slots. The term "shooting" guard appears to be apt—while 3PT% and FT% are insignificant for all other positions, both are significant for shooting guards. Seniority seems to be of particular importance for shooting guards and power forwards, as evidenced by the coefficients and t-stats for *TWOYEAR*, *THREEYEAR*, and *FOURYEAR*, but not for the other positions. While *AGE* and *HEIGHT* are significant for both shooting guards and small forwards, only *WIN%* is significant for small forwards, but not for shooting guards. Again, this could be a result of sample size, but the results are nonetheless rather surprising.

For centers, we find significance for four of the basketball statistics variables—*POINTS*, *ASSISTS*, *BLOCKS*, and *2PT%.* Two-point percentage is perhaps of great importance for centers because tall players that are able to play above the rim, and are therefore apt to have a high two-point percentage, are of great value to NBA executives. *POWERCONF*, *AGE*, and (marginally) *HEIGHT* are also significant for centers.

Additional data collection in the coming years may allow for a more thorough analysis, but the results from Table 4 display a surprising degree of disparity. Considering the results from all regressions, one can clearly see that *POINTS* is important for players at every position, but beyond this finding, the factors determining draft position seem to vary not only by position, but also by the number of collegiate years in which a prospect competes.

V. Conclusions

Using data from basketball-reference.com and realgm.com, we estimate models predicting a player's draft position in the annual NBA draft. Based on the performance of players during their final year of college, we find that points-scoring per-40-minutes is probably the most consistently influential variable in determining a player's draft position. This result closely resembles prior research by Berri [2005] and Berri, Brook and Fenn [2011]. Aside from scoring points, the results for the regression containing all players indicate that players attaining a higher rate of assists, steals, and blocks can expect to earn a better draft position than otherwise similar players. We also find that players with a higher two-point shooting percentage appear to enjoy better draft results. Interestingly, we do not find significant results for the other basketball-specific variables. Free-throw and three-point percentage appear to have no bearing on draft position. Likewise, the rate of rebounds and turnovers are also insignificant.

We find that players from more successful college teams tend to earn a boost on draft day; a ten-percentage point increase in winning percentage for a player's college basketball team is associated with a two-slot improvement in draft position. We also find that playing for a more experienced coach seems to improve a player's draft stock, while the winning percentage for each coach is not found to be significant.

Relative to four-year players, we find that players that cut their college careers short in order to enter the NBA draft tend to be drafted earlier. This is not surprising since these "early-entrants" are often the players with the most potential. Finally, we find that taller players have an edge over other prospects, but we do not find that a player's body-mass index has any bearing on draft position, save for the regression including only point guards.

Aside from the primary model, we estimate seven additional models. For the first two of these alternative models, we divide the dataset between "early-entrants" and players that spend a full four-years in college. The additional five models are broken down by position (PG, SG, SF, PF, and C). Surprisingly, we find great discrepancies among all of these models, indicating that the variables that impact draft selections vary greatly depending on the specific player. For example, three-point percentage is not found to be significant in the regression for all players, but is significant for both four-year players and for shooting guards. As years pass and more data can be collected, it will be interesting to see if such results persist.

The NBA landscape is fraught with many characteristics that lead to an unbalanced league. While salary caps are meant to mitigate these problems, some cities and franchises are simply more desirable for NBA players. However, the NBA draft is one avenue through which any franchise has the ability to improve, and indeed, selections in the NBA draft are often the defining factors for franchises. One needs to look no further than the NBA's current winningest team, the Golden State Warriors, who are reaping the rewards of shrewdly drafting Draymond Green, Klay Thompson, and two-time reigning MVP Steph Curry. Due to the great importance of the NBA draft and the sparse landscape of NBA draft research, a study on the NBA draft was needed. Analyzing only the drafts that occurred after the 2005 rule change, in which players were required to take a one-year break between high school and the NBA, we find many interesting results in predicting the determinants of draft position. Most notably, we show that player selection in the NBA varies among positions; for example, passing is held at a premium for point guards and centers. While it may seem obvious that the skillsets valued in the NBA would differ among player positions, prior research has generally lumped all players into a given model, which obscures that true value of player characteristics.

These findings will likely be of interest to sports economists, but we hope that our results are also intriguing to a general audience. The NBA draft, like many drafts in professional sports, offers a rare chance to see a labor market operate in a one-sided fashion. The demand side (NBA franchises) has complete autonomy in the labor process, while the supply side (players) are forced to accept whatever fate befalls them on draft night. As such, the results from the NBA draft are determined entirely by the demand side of the labor market. This greatly differs from most labor markets—for example, in the market for academic economists, both the demand (universities) and the supply (professors) are directly involved in the job-matching process and both sides must agree upon an arrangement before a hiring decision is made. While our research certainly took a basketball-centric approach, we hope that future researchers will consider the merits of studying the demand-dominated labor market offered by the NBA draft.

Endnotes

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[i]. Rookie contracts for first-round draftees last a guaranteed two years; these contracts provide teams with the opportunity to re-sign players for their third and fourth seasons at their discretion. Thus, there is a four-year window in which high-achieving players are often grossly underpaid relative to veterans.

[ii]. This position-adjustment method was also utilized by Berri, Brook, and Fenn [2011].

[iii]. As previously mentioned, the Berri, Brook, and Fenn [2011] paper utilized total values for each basketball variable, rather than the per-40-minute approach utilized in the current study. In order to compare the validity of these two approaches, we estimated a model that contained both styles of variables simultaneously. We found that the "total" variables were not significant, while the per-40-minute variables maintained most of their significance. This lends credence to our argument that the totals variables are inherently biased since not all teams and players play the same number of minutes; utilizing per-40-minutes is a more logical approach to gaging college performance.

[iv]. In addition, the coefficients for TWOYEAR, THREEYEAR, and FOURYEAR are all significantly different form each other at the 0.05 level of significance.

[v]. The inclusion of both AGE and the number of collegiate seasons may warrant concerns of multicollinearity. To investigate this potential problem, we calculated variance inflation factor (VIF) for each independent variable in all regressions. A VIF of ten is usually seen as problematic; all of our VIF values fall far below this value and only one variable exceeds four in any regression. Thus, we conclude that multicollinearity is not a major concern.

Table 1. Summary Statistics for all data and by collegiate years

	All Players		Early Entrants		Four-year Players	
Variable	**Mean**	**St.d.**	**Mean**	**St.d.**	**Mean**	**St.d.**
Draft#	24.049	13.665	19.591	12.807	31.773	11.517
Points	19.694	3.965	19.428	3.820	20.154	4.176
Assists	3.005	1.855	3.094	1.934	2.851	1.703
Rebounds	8.353	3.336	8.396	3.400	8.279	3.230
Steals	1.475	0.627	1.528	0.647	1.382	0.580
Blocks	1.353	1.312	1.380	1.335	1.305	1.273
Turnovers	2.822	0.762	2.914	0.797	2.662	0.670
2PT%	53.070	5.423	52.711	5.335	53.692	5.534
3PT%	30.921	16.859	30.660	16.661	31.374	17.236
FT%	72.622	9.669	72.043	9.390	73.626	10.084
WIN%	72.763	13.008	72.850	13.745	72.612	11.661
POWERCONF	0.802	0.399	0.839	0.368	0.738	0.441
COACHWIN%	65.328	8.885	65.952	8.972	64.247	8.651
COACHEXP	13.887	9.658	14.094	9.731	13.529	9.547
ONEYEAR	0.174	0.380	0.275	0.447	-	-
TWOYEAR	0.213	0.410	0.336	0.473	-	-
THREEYEAR	0.247	0.432	0.389	0.488	-	-
FOURYEAR	0.366	0.482	-	-	1.000	0.000
AGE	21.495	1.357	20.843	1.207	22.625	0.704
HEIGHT	78.985	3.249	78.960	3.323	79.029	3.126
BMI	24.681	2.102	24.618	2.336	24.789	1.619
PG	0.179	0.384	0.195	0.397	0.151	0.359
SG	0.232	0.423	0.245	0.431	0.209	0.408
SF	0.196	0.397	0.191	0.394	0.203	0.404
PF	0.226	0.418	0.191	0.394	0.285	0.453
C	0.168	0.374	0.178	0.383	0.151	0.359
n	470		298		172	

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Table 2. Summary Statistics by Position

	Point Guards		Shooting Guards		Small Forwards		Power Forwards		Centers	
Variable	**Mean**	**St.d.**	**Mean**	**St.d.**	**Mean**	**St.d.**	**Mean**	**St.d.**	**Mean**	**St.d.**
Draft#	23.833	13.730	25.211	12.954	22.380	13.350	25.811	13.337	22.253	15.158
Points	19.919	4.340	20.443	4.024	19.812	3.963	19.461	3.578	18.594	3.791
Assists	5.743	1.682	3.374	1.262	2.476	1.085	1.923	0.930	1.653	0.944
Rebounds	4.793	1.303	5.873	1.995	8.604	2.181	11.126	2.273	11.547	1.999
Steals	1.888	0.619	1.652	0.675	1.544	0.550	1.223	0.443	1.046	0.447
Blocks	0.333	0.278	0.535	0.353	1.211	0.974	1.922	1.086	2.966	1.497
Turnovers	3.233	0.847	2.755	0.738	2.637	0.692	2.745	0.741	2.794	0.664
2PT%	49.720	4.717	50.883	3.861	52.587	5.151	55.497	5.244	56.954	4.716
3PT%	36.263	5.837	36.474	6.135	34.847	8.479	26.967	20.092	18.315	26.816
FT%	77.336	7.916	76.375	7.171	74.433	8.035	68.626	9.557	65.684	10.395
WIN%	73.506	12.362	71.248	13.409	74.452	12.880	71.163	12.925	74.243	13.214
POWERCONF	0.738	0.442	0.798	0.403	0.826	0.381	0.821	0.385	0.823	0.384
COACHWIN%	64.648	9.999	65.117	7.802	65.999	8.470	65.026	8.939	65.966	9.543
COACHEXP	14.095	10.608	13.202	9.404	13.359	9.309	13.953	9.149	15.139	10.111
ONEYEAR	0.190	0.395	0.156	0.364	0.130	0.339	0.189	0.393	0.215	0.414
TWOYEAR	0.286	0.454	0.183	0.389	0.261	0.442	0.170	0.377	0.177	0.384
THREEYEAR	0.214	0.413	0.330	0.472	0.228	0.422	0.179	0.385	0.278	0.451
FOURYEAR	0.310	0.465	0.330	0.472	0.380	0.488	0.462	0.501	0.329	0.473
AGE	21.371	1.298	21.429	1.218	21.631	1.405	21.530	1.361	21.511	1.545
HEIGHT	74.429	1.832	77.009	1.430	79.620	1.274	81.113	1.214	82.962	1.652
BMI	23.894	2.163	24.410	1.291	24.050	2.695	25.543	1.921	25.468	1.720
n	84		109		92		106		79	

Table 3. Estimating Draft Selection for all players and by number of collegiate seasons

	All Players		Early Entrants		Four-Year Players	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Points	-4.082***	-6.92	-4.398***	-5.52	-3.787***	-4.17
Assists	-1.501***	-2.61	-2.141***	-3.02	-0.937	-0.94
Rebounds	-0.511	-0.91	0.492	0.72	-2.228**	-2.30
Steals	-1.029*	-1.95	-1.005	-1.63	-0.943	-0.92
Blocks	-1.990***	-3.65	-2.650***	-3.67	-1.092	-1.27
Turnovers	0.098	0.17	0.656	0.88	-1.278	-1.25
2PT%	-1.507***	-3.02	-1.925***	-3.07	-0.779	-0.92
3PT%	-0.783	-1.53	-0.336	-0.55	-2.42**	-2.56
FT%	-0.396	-0.71	-0.387	-0.54	-0.395	-0.44
WIN%	-0.200***	-4.40	-0.169***	-3.20	-0.285***	-3.34
POWERCONF	-3.518***	-2.68	-5.761***	-3.20	-2.394	-1.24
COACHWIN%	0.017	0.25	-0.022	-0.25	0.145	1.32
COACHEXP	-0.117**	-2.13	-0.130*	-1.87	-0.025	-0.28
TWOYEAR	4.056**	2.36	3.298*	1.86	-	-
THREEYEAR	4.323**	2.20	2.794	1.33	-	-
FOURYEAR	8.507***	3.67	-	-	-	-
AGE	3.612***	6.17	4.095***	5.97	1.798	1.55
HEIGHT	-1.438***	-2.79	-2.363***	-3.61	-0.478	-0.56
BMI	0.231	0.47	0.870	1.53	-1.591	-1.60
SG	0.436	0.30	0.861	0.49	1.260	0.48
SF	-2.831*	-1.88	-3.970**	-2.15	-0.145	-0.05
PF	0.224	0.15	-1.353	-0.73	2.604	1.09
C	-2.000	-1.27	-2.943	-1.56	0.204	0.07
Intercept	-42.853***	-3.42	-48.098***	-3.15	-2.589	-0.10
n	470		298		172	
R^2	0.52		0.50		0.44	

Table 4. Draft Selection by Position

	Point Guards		Shooting Guards		Small Forwards		Power Forwards		Centers	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Points	-1.146**	-2.48	-0.839**	-2.25	-1.040***	-3.00	-0.770**	-2.09	-1.307***	-3.11
Assists	-2.648**	-2.56	0.313	0.25	0.410	0.31	-1.483	-1.09	-5.104**	-2.44
Rebounds	-1.332	-1.24	0.647	0.79	0.176	0.25	-0.309	-0.51	-0.841	-1.18
Steals	-1.887	-0.80	-3.293*	-1.86	-3.546	-1.48	0.626	0.24	-5.720	-1.50
Blocks	-6.885	-1.11	-11.344***	-2.89	0.049	0.03	-0.913	-0.81	-3.303**	-2.63
Turnovers	2.649	1.23	-0.724	-0.31	-2.104	-0.98	-0.170	-0.10	0.401	0.17
2PT%	-23.905	-0.66	-0.239	-0.01	5.201	0.22	-26.728	-1.05	-68.041**	-2.17
3PT%	-14.012	-0.50	-54.412***	-2.69	-7.630	-0.47	-2.587	-0.43	4.490	0.84
FT%	4.594	0.22	-35.839*	-1.98	11.855	0.74	1.272	0.08	-1.771	-0.12
WIN%	-0.044	-0.30	-0.044	-0.44	-0.310***	-2.87	-0.241**	-2.34	-0.136	-0.95
POWERCONF	-2.400	-0.65	-3.275	-1.10	-3.777	-1.17	-1.000	-0.32	-9.543**	-2.33
COACHWIN%	-0.192	-1.12	0.039	0.22	0.042	0.24	0.015	0.10	0.121	0.58
COACHEXP	-0.170	-1.06	-0.144	-1.17	0.163	1.13	-0.081	-0.61	-0.073	-0.43
TWOYEAR	-3.119	-0.69	10.166**	2.58	2.647	0.60	7.475**	2.01	-1.201	-0.25
THREEYEAR	-0.622	-0.12	10.144**	2.25	0.728	0.14	14.221***	2.99	-2.227	-0.43
FOURYEAR	-8.357	-1.30	11.758**	2.16	8.946	1.42	22.097***	4.07	3.927	0.67
AGE	7.983***	4.83	4.221***	2.86	2.603*	1.87	0.338	0.23	3.824**	2.62
HEIGHT	0.133	0.15	-2.243***	-2.70	-2.019**	-2.16	-0.518	-0.55	-1.958*	-1.77
BMI	1.422**	2.18	-0.565	-0.64	-0.164	-0.37	-0.187	-0.29	0.817	0.82
Intercept	-108.959	-1.20	183.472**	2.06	166.404*	1.99	104.998	1.24	183.450	1.66
n	84		109		92		106		79	
R^2	0.63		0.61		0.66		0.62		0.72	

References

Berri, David J. & Martin B. Schmidt. 2010. *Stumbling on wins: Two economists expose the pitfalls on the road to victory in professional sports.* Upper Saddle River, NJ: Pearson Education.

Berri, David J., Stacey L. Brook, & Aju J. Fenn. 2011. From college to the pros: predicting the NBA amateur player draft. *Journal of Productivity Analysis,* 35: 25-35.

Berri, David J. 2005. Economics and the national basketball association: surveying the literature at the tip-off. In: Fizel J (ed) *The handbook of sports economics research.* M.E. Sharpe, Inc, London, 21–48.

Groothuis, Peter A., James Richard Hill, & Timothy Perri. 2007. Early entry in the NBA draft: The influence of unraveling, human capital, and option value. *Journal of Sports Economics*, 8(3), 223-243.

Ichniowski, Casey & Anne E. Preston. 2012. Does March Madness lead to irrational exuberance in the NBA draft? High-value employee selection decisions and decision-making bias. NBER Working Paper Series. <http://www.nber.org/papers/w17928.pdf>

Krautmann, Athony Charles, Peter von Allmen, & David J. Berri. 2009. Underpayment of restricted players in North American Sports Leagues. *International Journal of Sport Finance*, 4, 161–175.

Motomura, Akira, K.V. Roberts, Daniel M. Leeds, & Michael Leeds. 2016. Does it pay to build through the draft in the National Basketball Association? *Journal of Sports Economics*, 17(5): 500-513.

Price, Joseph, Brian P. Soebbing, David J. Berri, & Brad R. Humphreys. 2010. Tournament incentives, league policy, and NBA team performance revisited. *Journal of Sports Economics,* 11, 117–135.

Rodenberg, Ryan M. & Jun Woo Kim. 2011. Precocity and labor market outcomes: Evidence from professional basketball. *Economics Bulletin*, 31(3), 2185-2190.

Soebbing, Brian P. & Brad R. Humphreys. 2010. Do gamblers think that teams tank? Evidence from the NBA. *Contemporary Economic Policy*, 31(2), 301-313.

Taylor, Beck A. & Justin G. Trogdon. 2002. Losing to win: Tournament incentives in the National Basketball Association. *Journal of Labor Economics*, 20(1), 23-41.

Thoreau's micro theory prescience in *Walden*, Chapter One: 'Economy'

Jeffrey Wagner*

*Department of Economics, Rochester Institute of Technology, 92 Lomb Memorial Dr., Rochester, New York 14623, jeffrey.wagner@rit.edu.

ABSTRACT
The first chapter of Henry David Thoreau's *Walden* (1854) entitled 'Economy' surprisingly anticipates multiple microeconomic concepts of contemporary concern. Three examples illustrate how microeconomic theory is circling back to Thoreau's insights. At the same time, while Thoreau is considered among the most impactful writers in American literature, the economics profession has struggled to impart its insights to the general public. As Arrow might say, Thoreau has the code. Economists need it. Reconsidering Thoreau's economic theory prescience enriches modern economic theory and policy, while enhancing economists' ability to communicate theory and policy proposals to non-economists.

INTRODUCTION

The introductory chapter of Henry David Thoreau's *Walden* (1854) entitled 'Economy' surprisingly anticipates multiple current topics of mainstream microeconomic theory concern and is among the most-read literary expressions in American history. Yet, consideration of Thoreau's impactful ideas in the economic literature is relatively thin. At the same time, economists recognize that the profession has a difficult time communicating its policy insights to the median voter and elected representatives. As a consequence of failing to communicate the merits of first-best policies and of not fully appreciating the concerns citizens have beyond efficiency—justice in particular—inefficient policy stalemate occurs and third-best ('business-as-usual') prevails as the baseline. The thesis forwarded in this paper is that economists should take another look at Thoreau's 'Economy' for insight to 'talking the talk' with non-economists. In so doing, economic policies are more likely to achieve the second-best over the third-best when first-best is politically out of reach, and policies are more likely to be viewed as just.

The economic literature regarding Thoreau's ideas basically comprises Fusfeld (1973) and Becker (2008). Fusfeld (1973, pp. 146-147) presents Thoreau as an economics radical in general, and a life-style radical in particular. He maintains that the radicalism Thoreau expresses in 'Economy' is "…the most eloquent statement of the philosophy of the life-style radical in the literature of American social thought" and that Thoreau railed against market institutions that promoted impersonal transactions and a focus upon material wealth. Instead, Thoreau emphasized the merits of reconnecting people with people, and each person with a direct sensory perception of their natural environments. Fusfeld implies that as an economics radical, Thoreau's perspectives are diametrically opposed to mainstream microeconomic analysis of how markets function and the moral context within which market outcomes can be evaluated. Becker (2008) provides a comprehensive analysis of Thoreau's economic philosophy, primarily comparing Thoreau's views with those of the classical economic views of his time. He notes (pp. 214-17) that Thoreau generally took a dim view of barter, trade, markets, and the division of labor, and that he did not believe the institution of private property was a necessary condition for human liberty. Becker suggests that Thoreau's critical assessment of mainstream economic theory is as relevant today as it was in Thoreau's time and is evident in some aspects of relatively new fields in economics such as ecological economics. He draws upon the entirety of Thoreau's writings rather than focusing his analysis upon the 'Economy' chapter, as is the focus in the present study.

The take-away message from the relatively thin but thought-provoking consideration of Thoreau in the histories of economic theory and economic thought is that his (radical) views are contrary to neoclassical microeconomic theory and therefore not of much contemporary value for mainstream economic policy-making. This paper takes a broader view of Thoreau's 'Economy' to argue (1) that with the passage of time, Thoreau's views that may have originally been taken as radically incompatible with neoclassical microeconomic theory actually proved prescient, as mainstream microeconomists are now circling back to market failure topics of Thoreau's concerns, and (2) that a reconsideration of Thoreau's prescience could usefully inform discussions as to how modern economic theory and policy might resonate more with the general public and its elected officials. Three specific examples of Thoreau's prescience are analyzed herein: Clubs/networks with entrapment—as in Dixit (2003); internalities—as in Allcott *et al.* (2019); and the upper bound of division of labor gains—as in Arrow (1974). In all three cases, the concepts of mainstream microeconomic theory concern are ones that Thoreau recognized as tangible market failures that should be of concern to all citizens.

Indeed, Thoreau's concern about cases of market failure does not imply that he had no use for classical (and now neoclassical) economic theory. Thoreau rather seems to have well understood (without celebrating) the mainstream microeconomic forces at work in his community and the social, historical context in which those forces operated. For example, Sattelmeyer (1988, p. 265) indicates that Thoreau would have read J. B. Say's *Treatise on Political Economy* as a student at either the Concord Academy or at Harvard (since the book is known to be required reading at both schools), and that Thoreau maintained an 1834 edition of Say's book in his personal library. Walls (2017, pp. 94, 259) describes Thoreau's many business ventures, some of them quite successful (e.g., she describes Thoreau working with his father in the pencil business and contributing valuable intellectual property to the enterprise) and she notes the hundreds of professional land surveys Thoreau carried out. To the extent that mainstream modern economists do not recognize Thoreau's contributions, economists miss important opportunities to present ideas in ways that resonate with the vast majority of the voting public that has taken few to no economics courses. For Thoreau must be considered among the most impactful writers in American literature (perhaps along with John Steinbeck and Mark Twain), particularly in terms of how many citizens—who have never taken a course in economics—have formed perceptions as to the strengths and weaknesses of modern markets.[1] After all, citizens have consumed much more economic perspective from literature, theatre arts, cinema, popular press, and music than from primary school, secondary school, and college economics courses. There is considerable research that looks at how people understand economic concepts and how that understanding evolves with age—usually in the absence of formal economics instruction in school but definitely in the presence of popular culture/media and in the context of each person's lived experience. Some of this discussion occurs within a strand of academic literature that focuses upon 'folk economics'.[2] There is also academic literature on how economic concepts are treated in theatre/drama, the history of the novel, and in poetry (e.g., in the works of N. Scott Momaday, Wendell Berry, and Václav Havel).[3] The point that appears to be overlooked in the literature thus far is that since popular culture/media and literature like Thoreau's *Walden* (rather than economics textbooks and lectures) are the primary conduits for shaping how most humans perceive economic dynamics—e.g., how 'free' markets generate socially optimal results, and how markets deal with fair distribution of economic opportunities and economic outcomes—we cannot be surprised that there are disconnects between professional economic perspectives and those of the general public and that there is public resistance to standard economic efficiency policy arguments.[4]

There is some recent recognition of this disconnect between the economics literature and the public policy-making that the literature seeks to inform. For example, Goulder (2020) rightly maintains it is not adequate for economists to focus upon pure efficiency arguments (that the voting public and their elected representatives and other stakeholders are not buying) when it comes to promoting stronger climate policies such as carbon taxes. His insight is that economists need to broaden the mainstream neoclassical microeconomic menus of policy alternatives they present to take into account the relative political costs of the alternatives. That is, based on Goulder (2020, pp. 10-11), if policy A (a carbon tax with tax revenue used to reduce distortionary taxes such as income taxes) is preferred to policy B (a carbon tax with revenue returned to households a la compensating variation) on strict neoclassical economic efficiency grounds, but policy B is preferred by the majority of stakeholders on equity grounds—and, as in the case of combatting

[1] Regarding Thoreau's impact on American literature and culture, see Sattelmeyer (2007, p. 11) who writes: "Not even Mark Twain, I would argue, Thoreau's only serious rival as a writer claimed at once by diverse publics and academic specialists, presents so thoroughgoing a conflation of literary artist and cultural property." And see Howarth (2017) on Thoreau's impact: "In this bicentennial year of Thoreau's birth, Walden, or "Life in the Woods" (1854), is still our most famous antebellum book. From the 1920s to the early 2000s, Walden was required reading in hundreds of thousands of US high school and college survey courses."

[2] See, e.g., Rubin (2003) and Boyer and Bang Petersen (2018).

[3] See, e.g., Watts and Smith (1989), Wagner (2004) and Wagner (2017).

[4] See, e.g., Haferkamp *et al.* (2009) regarding the divergence between economic perspectives held by laypeople as opposed to professional economists.

climate change, the social costs of policy delay are substantial—policy B may in fact yield greater net benefits than policy A. A second example from environmental economics is described by Schmalensee and Stavins (2017, p. 63). They point out that a key lesson from the implementation of the tradeable market for sulfur dioxide emission permits under the 1990 Clean Air Act Amendments is that giving polluters a free initial allocation of permits "…can be very useful for building political support" for an economically efficient emission control program, even though the free initial allocation is not motivated by standard economic efficiency arguments.[5]

A third, different type of example is presented in Chetty's (2015) American Economic Association Ely Lecture. He describes several examples of the mainstream neoclassical microeconomic model of consumer decision-making serving as a special case of a more realistic framework in which behavioral factors lead consumers to make decisions that appear to be sub-optimal when viewed through a strict neoclassical micro lens. Chetty maintains that it is most productive for the relatively new behavioral economics field to focus upon how the inclusion of behavioral factors enriches the neoclassical microeconomic paradigm rather than focusing upon how the existence of behavioral factors in various contexts shows that the assumptions of the neoclassical paradigm are unsound.

To summarize, Thoreau seemed to pretty well understand the conceptual strengths and shortcomings of modern, mainstream competitive markets. Like contemporary, mainstream neoclassically-trained economists, however, he was concerned that the received wisdom as to why people do what they do was incomplete; he was concerned about situations in which untethered market forces could lead to individually and socially inferior outcomes; and he was concerned about the extent to which market outcomes would also comport with social justice. A key difference is that Thoreau's expressions of those concerns have resonated with a massive number of people for over 160 years, whereas the public bandwidth of concerns raised by contemporary academic economists seems—I don't think it's controversial to say—much less. Hence, there is something to be gained by economists in taking a fresh look at Thoreau's 'Economy'—specifically for insights to 'talking the talk' with legislators, public-policy makers, and general public voters.[6]

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[5] A complementary example of deviating from pure economic efficiency arguments in order to solidify political support for the tradeable permit market was Congress's decision to permit citizen participation in the market. Strictly sub-optimal solutions, if they greatly reduce citizen opposition, may in fact be the optimal choice given political constraints. Given substantial costs of delayed action, it may be that as Goulder (2020) suggests, society can gain by deviating from pure economic efficiency. See Malueg and Yates (2006) for further evaluation of permitting citizen participation in tradeable emission permit markets.

[6] Consider also the terrific success of Lin-Manuel Miranda's 'Hamilton' production in tapping into and raising citizen awareness to not only the economic forces in their contemporary lives but also to how long ago certain forces were set into motion that still exert strong influence—much as Prof. Paul David's (1985) concept of economic 'dark stars'. Miranda's presentation of the socioeconomic tensions surrounding the initial funding of the government (during the Revolutionary War to the 1790 Assumption Act) that are still

The paper proceeds as follows. Section II describes Thoreau's anticipation of the modern microeconomic theory of networks and the social challenge of managing path-dependence to avoid inefficient entrapment, as featured in Dixit's (2003) model of club formation with entrapment. Thoreau's concern for what modern microeconomists call 'internalities'—as analyzed in Allcott *et al.* (2019)—is set forth in Section III. Section IV relates Thoreau's views to Arrow's (1974) discussion of the strengths and weaknesses of an increasingly narrow division of labor. Conclusions are presented in Section V.

CLUBS WITH ENTRAPMENT, NETWORK GOODS, AND PATH-DEPENDENCE

'Economy' is the first and longest chapter in Thoreau's *Walden*. There are several themes of economic interest raised by Thoreau in this chapter; the analysis in this paper focuses upon just three. The first of those—in no particular order—is Thoreau's anticipation of the modern microeconomic theory of networks and the social challenge of managing path-dependence to avoid inefficient entrapment, as featured in Dixit's (2003) model of club formation with entrapment. Dixit studies the following question: Could a network or technology or institution arise in which a large proportion of consumers are entrapped to join/adopt and are worse off compared to the scenario in which the network/technology/institution did not exist? The answer from his mainstream microeconomic theory model is "yes" and he derives the conditions under which this problematic outcome obtains. The motivation for his study was the introduction of the European Union institution, wherein some countries were quite eager to join whereas others were wary. As time unfolded, the wary could no longer choose from an option list that included 'European Union does not exist'. Rather, the options were 'Join' or 'Not Join' now that *n* other countries have joined. As Dixit emphasizes, the fact that the choices by *n* others affect the relative payoffs to the next country weighing the decision creates network externalities that confound the countries' underlying preferences toward joining or not. Indeed, he considers a wide range of examples beyond the formation of the European Union—including the proliferation of cellphones—and it is perhaps the cellphone example that best illustrates how consumers who resist that technology are entrapped by two types of network effects. First, as more of one's family and associates join the cellphone network, the benefits to joining with them increases—independent of how one feels in the abstract about owning a cellphone. But at the same time, as more people join the cellphone network, the quality of the status quo option (relying upon landlines and payphones) diminishes. After all, as Dixit notes, payphones disappeared rapidly from the landscape as they fell into disrepair and were not replaced. Thus, in Dixit's model, observing someone opt to join a cellphone network may say very little about that someone's true preferences; their preferences may be swamped by these two entrapping types of network effects and that someone may in fact be solving a loss-minimization problem rather than a utility-maximization problem.

with us today reached a far broader audience of voters and policy-makers than all of the excellent economic research on this topic *combined*. It is not just the digital media that accounts for this reach; it is the message that many citizens are equally if not more concerned about matters of equity and justice as they are about efficiency.

The most troubling aspect of this from a mainstream social welfare maximization point of view is Dixit's result that this could be the state of affairs for a *majority* of members of the network rather than just for—as Dixit (p. 1824) aptly puts it—"a few nostalgics or curmudgeons".[7]

What does this have to do with Thoreau and his 'Economy'? A key theme of Thoreau's concern is his fellow citizens' need to be mindful of becoming locked into institutions, technologies, and habits of living that may in fact not be optimal. He recognizes that in the presence of network effects, institutions and technologies that may at first yield a lot of private and social good can evolve in ways that limit the real options individuals face, entrapping some (and perhaps a majority) in inferior outcomes. For example, Thoreau (p. 10) writes "I see young men, my townsmen, where misfortune it is to have inherited farms, houses, barns, cattle, and farming tools; for these are more easily acquired than got rid of…Who made them serfs of the soil?" Later, he writes (p. 12) "I have lived some thirty years on this planet, and I have yet to hear the first syllable of value or even earnest advice from my seniors." He criticizes (on p. 20) the social pressure to conform on matters such as whether one has patches on one's clothes. Finally, he writes (on pp. 27-28) "Most men appear never to have considered what a house is, and are actually though needlessly poor all their lives because they think that they must have such a one as their neighbors have."

The above passages from 'Economy' anticipate Dixit's concern for entrapment by calling our attention to the impact of potentially inefficient social forces upon individual decision-making. But that is not all; Thoreau's observations regarding entrapment preview complementary concepts discussed by contemporary, well-known economists David (1985), Frank (2008), and Heal and Kunreuther (2010), among others. David (1985) uses the QWERTY keyboard's persistence in society amidst more efficient keyboard layouts as an example of inefficient path-dependence, suggesting that this is but one example of many 'dark stars' far away in space and time that nevertheless exert important influences in today's economy and society. Frank (2008) introduces the concept of 'positional externalities' wherein one consumer's choices can inefficiently change the position—i.e., 'raise the bar'—against which other consumers assess their own utility. One example he proposes regards housing. If consumers gain utility from housing that is large relative to the size of their peers' housing, and peers move to even larger houses, then consumers who do not also move to ever larger houses and join what amounts to a 'positional arms race' suffer a drop in utility—even if in an absolute sense their current housing is quite spacious. The peer group's choice of housing creates a positional externality for individuals in the peer group and it is not obvious that the result is individually or socially optimal. Frank argues that it is not unreasonable—and may indeed be necessary—for public policy to rein in positional externalities. Heal and Kunreuther (2010) address the topic of social reinforcement vis-à-vis cascades, entrapment and tipping—all concepts that arise when one agent's actions may influence the actions of other agents—and propose a general model of such influence as 'games with increasing differences'. Like David (1985), they suggest that the continued presence of the QWERTY keyboard may

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[7] In full disclosure, I am told I am one of those curmudgeons—one of the last, it seems, entrapped to take up a smartphone only in January 2020.

be evidence of inefficient social reinforcement and they also cite Dixit's (2003) analysis of clubs with entrapment. Heal and Kunreuther (2010, 88) find that if there are two equilibrium outcomes to a game (dynamic process) and one of them Pareto-dominates, then there is a coalition of agents whose choices can tip the game/dynamic to the efficient outcome. They then proceed to characterize the size of the smallest coalition needed for such tipping, as a function of the game's parameters.[8]

Imagine Thoreau with an opportunity to participate in an AEA conference session along these lines with Dixit, David, Frank, Heal and Kunreuther! Would they not be on the same page? Arguably all of these scholars would agree that socially contingent or reinforced economic behavior is the norm rather than the exception in environmental quality and other challenges; that 'races to the bottom' and 'entrapment' are to be avoided when feasible; that public policy can tip individual and social decision-making from inefficient ones to Pareto-superior ones; and that such policy-making should complement rather than substitute for free market forces.

INTERNALITIES

The argument in the previous section is that Thoreau anticipated modern neoclassical microeconomic theory with respect to concerns that consumers may be entrapped by network or social reinforcement effects into making inefficient choices. The basic idea is that consumers end up choosing from an inefficiently constrained set of options. A related concern to both Thoreau and modern microeconomists is that consumers may take sub-optimal decisions for any number of behavioral economic reasons, even when consumption possibility sets are not constrained by network effects. An entire field of microeconomics—behavioral economics—now complements neoclassical microeconomic theory in striving to well-understand and better predict consumer decision-making in a wide range of settings. Behavioral economic research explores how consumers may make systematic mistakes or misjudgments that lead to privately sub-optimal decision-making. Reducing one's potential utility by making systematic mistakes or misjudgments is known in the literature as incurring an 'internality'. Hunt Allcott is a leading authority on this topic, and Allcott *et al.* (2019, pp. 210-11) offer a recent analysis of internalities in the context of considering taxes on sugar-sweetened beverages. They suggest that consumers of sugar-sweetened beverages may incur internalities because of (1) incomplete information as to how such beverages impact one's health and (2) issues of self-control and time inconsistency that leads them to inefficiently discount future health costs. Hence, placing a

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[8] A complementary theme is pursued in Nyborg *et al.* (2006), who show that temporary subsidies for green behavior such as household-level recycling may be necessary for tipping the 'recycling game' from a Nash equilibrium in which no one recycles to the Pareto-preferred Nash equilibrium in which everyone recycles. The subsidies may only need to be temporary because if individual recycling behavior is socially contingent, then non-recyclers only need to see a sufficient number of others engaged in it to join the movement; then social reinforcement takes over as a snowballing effect that converges to the outcome in which everyone is recycling.

tax on sugar-sweetened beverages can counteract the internality—the behavioral instinct to overweight the short-run—by enabling more consumers to maximize what is in fact their long-run utility.

How does Thoreau see the concept of internality? He writes (p. 10) “Men labor under a mistake” and continues (p. 11) “Most men, even in this comparatively free country, through mere ignorance and mistake, are so occupied with the factitious cares and superfluously coarse labors of life that its fine fruits cannot be plucked by them.” Continuing on p. 12, he (famously) states “The mass of men live lives of quiet desperation.” And he continues later on that page, “Yet they honestly think there is no choice left. But alert and healthy natures remember that the sun rose clear.” In each case, Thoreau suggests that at the core, human beings either know their self-interest but sometimes (if not often) misperceive social forces and make mistakes, or that they do not know their self-interest but are quite capable of being nudged to learn their self-interest. Thoreau’s overarching purpose in ‘Economy’ is to appeal to his fellow humans’ ‘alert and healthy natures’ to not ‘live lives of quiet desperation’ and of ‘factitious cares’ but instead to exercise *agency*—to be vigilant against inefficient, sticky social forces that can carry one away from one’s best interest. Thoreau goes further than making an appeal, however. In classic georgic literary mode, he sets forth in ‘Economy’ a step-by-step user guide for reclaiming one’s agency and realizing the internalities in one’s life for what they are.[9] He leads by example and beckons readers to come along—to walk right out of the economy and society—and recalibrate one’s sensory antennae to the unambiguous fundamentals of life—food, shelter, and close friendship/companionship, organized and pursued with a keen awareness of and alignment to the natural forces governing ecosystem functions. Grounded thus, internalities are far easier for individuals to recognize and to keep at bay. Arguably, the strong persistence of Thoreau’s *Walden* in the global literary canon, notwithstanding the tremendous technological and economic gains accrued in the world since it was published and the complexification of life that that entails, substantiates Thoreau’s instinct that individuals across all space and time crave holding onto agency—fending off internalities—and that a foolproof, step-by-step plan for doing so would be a best-seller.

Many other economists besides Allcott and colleagues are concerned with internalities and devising policies to assist consumers who systematically take sub-optimal decisions. In addition to Chetty’s (2015) American Economic Association Ely Lecture along these lines, summarized earlier, Campbell (2016) describes in his own AEA Ely Lecture considerable evidence that households make many mistakes in their financial decisions. Thoreau would nod his head and say, “Yes, we need to intervene in markets and, as Campbell indicates in his Conclusion, do even more than has been done already to introduce behavioral nudges in order to get the right outcomes.” Most recently, Shaffer (2020) finds that a non-negligible number of electricity consumers routinely misunderstand nonlinear pricing schedules—namely, that a marginal price

[9] See Wagner (2013) for an introduction to the georgic literary mode employed by several well-known American writers including John Steinbeck, Willa Cather, Robert Frost, and Thoreau, whereby writers impart life observations and lessons but also instructions. See Walker (1998) as well on the importance Thoreau placed upon people exercising their agency and on the user-guide quality of his *Walden*.

is the price of the last unit and not the price of all units consumed. He shows that the welfare loss to households that misperceive nonlinear pricing in this manner amounts to 10% of their annual electricity expenditures. Shaffer concludes his study by cautioning policy planners that well-designed (economically efficient) energy policies may fail to reach their goals if consumers misperceive how first-best energy pricing structures actually work.

In all of the above studies—published in top journals in the economics profession—the theme is that if the first-best policy that economists design is not readily understood or believed by agents, then the internalities they suffer could yield more deadweight loss than the deadweight loss that would accrue from a second-best but clear policy. That is, first, second and third-best welfare-generating policies are almost always ranked that way by economists in a world in which agents are assumed to understand what prices reflect and how markets function within their socioeconomic, legal system; if agents don't understand—or trust—one or more aspects of that world, what was a first-best policy can easily fall to third-best. Thoreau raises our awareness to this fact—and has been doing so for a long time, in language that reaches a far larger audience than even our most famous economic policy designers and proponents.

EXTREME DIVISION OF LABOR

Let us turn now to a third important modern microeconomic concept that Thoreau anticipates in 'Economy' and that regards how extremely to specialize/divide labor in supply chains. This one of the oldest economic concepts on the planet, appearing in works at least as far back as Plato's *Republic* in 380 BC and made yet more famous by Adam Smith in the first two chapters of his 1776 *Wealth of Nations*. The concept remains central to modern evaluations of globalization and economists no less influential than Kenneth Arrow, Gary Becker and Kevin Murphy have contributed to our understanding of the strengths and weaknesses of forging an ever-finer division of labor on a global scale. Arrow (1974) addresses this topic in four essays that address the opportunities and challenges of technology that enables significant increases in information flow and how we may expect such flows to motivate finer and finer specialization of labor—with attendant opportunities and challenges. The most salient points, in Arrow's own words, are as follows:

"The essential considerations are two: (1) individuals are different and in particular have different talents, and (2) an individual's efficiency in the performance of social tasks usually improves with specialization. We need cooperation to achieve specialization of function." (p. 49). "The need for codes mutually understandable within the organization imposes a uniformity requirement on the behavior of the participants. They are specialized in the information capable of being transmitted by the codes, so that…they learn more in the direction of their activity and become less efficient in acquiring and transmitting information not easily fitted into the code." (p. 56). "…once an information channel (is) acquired, it will be cheaper to keep on using it than to invest in new channels…." (p. 41). And "…the very pursuit of efficiency may lead to rigidity and unresponsiveness to further change." (p. 49).

A key theme that emerges in Arrow's text is that the necessary code for managing increasingly large flows of information in the globalizing economy is a double-edged sword and it is not obvious that our market and social institutions are equipped to find the efficient edge. On one hand, codes such as computer programming, digital information, and artificial intelligence enable evermore-efficient trade. On the other hand, a greater flow of trade does not imply a greater flow of welfare; it is possible for the flow to become locked into a rigid track that, as Arrow cautions, may be 'unresponsive to further change.'

Arrow's insights regarding the division of labor complement previous discussions of academic literature in this paper regarding clubs with entrapment and internalities—all of which were of keen interest to Thoreau. As Gilmore (1985) and Walker (1998) emphasize, Thoreau was particularly animated on the interrelated topics of market exchange and the alienating division of labor that market exchange entails. He was quite concerned that individuals maintain their individuality and their autonomy as much as possible from market forces, especially those forces pulling workers toward assembly lines and away from self-production. Thoreau lamented that intense specialization had even invaded the practices of farming, where Thoreau believed strongly in what scholars now call Jeffersonian political economy that held small family farms to be the core of sustainable economies and societies. What does Thoreau specifically write in 'Economy' about the division of labor concept? "I cannot believe that our factory system is the best mode by which men may get clothing." (p. 22). "Where is this division of labor to end? And what object does it fully serve? No doubt another may also think for me; but it is not therefore desirable that he should do so to the exclusion of my thinking for myself." (p. 34). And, "…following blindly the principles of a 'division' of labor to its extreme, a principle which should never be followed but with circumspection." (p. 36).

Thoreau's instinct for circumspection is to a large degree just what Arrow suggests. Each would agree that the privately and socially optimal intensity of specialization of labor is not zero nor is it unbounded; rather, each describes marginal benefits and marginal costs to specialization of increasing intensity. Their circumspection suggests that there is a positive but bounded optimal degree of specialization where, as we economists are prone to say, the marginal cost just equals the marginal benefit. Arrow's observations suggest that estimating this crossing point is difficult and that much work remains to be done; Thoreau would concur.

Economists since Arrow (1974) have further investigated economic properties of finer and finer specialization of labor. For instance, Becker and Murphy (1992, 1138) argue that while Smith claims that the benefits from the division of labor are limited primarily by the 'extent of the market', what is more likely the limiting factor is the increased cost of coordinating specialized workers in larger and larger groups.[10] Agha *et al.* (2019), citing Becker and Murphy, investigate the impact of some of these coordination costs in the health care market and find that greater fragmentation of care amongst specialists that need to coordinate their diagnoses and prescriptions may raise care costs but may also raise the quality of care (suggesting

[10] Becker and Murphy (1992, p. 1138) write: "A variable of great importance is the cost of combining specialized workers. Modern work on principal-agent conflicts, free-riding, and the difficulties of communication implies that the cost of coordinating a group of complementary specialized workers grows as the number of specialists increases."

that Arrow, Becker, Murphy, and Thoreau are correct that there exists a positive but bounded optimal rate of specialization). Coviello *et al.* (2019) find that when judges are assigned streams of cases in the same area of law, they are effectively specializing and their data shows that such judges close cases more quickly—move through more cases per time period—with no statistical change in quality, as measured by appeal rates of their decisions. These papers emphasize the positive results of increasingly fine specialization per se, and while there may be private coordination costs that limit the fineness of specialization, they do not consider whether such specialization may impose negative social impacts beyond the private coordination costs.

Yet, these negative social impacts are on the minds of the median voter—the same median voter that probably has not taken an economics course in college and whose support we need in order for us to implement relatively efficient policies. And while economics scholars tend to focus upon the positive aspects of narrow specialization, scholars outside of economics tend to focus upon the challenges narrow specialization poses. For instance, with respect to the aforementioned benefits of increased specialization in the US courts, Wasserman and Slack (2021) describe how the historical view that *avoiding* judicial specialization is preferable is giving way to greater specialization in opinion writing, if not in court venues. They write on their p. 5 “Perhaps most concerning, this Article contends that opinion specialization in specialized courts increases the likelihood that doctrine reflects the idiosyncratic preferences of a few judges.” Porter (2003), Reinstein and McMillan (2004), and articles in any issue of the *Journal of Money Laundering Control* or the *Journal of Cybersecurity* bring into sharp relief the negative socioeconomic externalities of fraud that arise proportionally with the degree of specialization in information and digital markets. These references discuss the significant challenge of preserving robustness in distributed, fragmented systems against rogue actors who, by definition of intense specialization, have skills perhaps no one else in the system possesses and whose actions may therefore be untraceable/unchecked/unaudited until long after the social damage is done.

To be sure, Thoreau is not the only literary figure to call attention to the double-edge sword of highly intense specialization of labor. For just one other example, consider the following commentary in Austrian novelist Robert Musil’s (1930, p. 696) *The Man Without Qualities*, which fellow Austrian writer Frederick Morton (1995) maintained in his review in *The Wall Street Journal* constituted one of the three great novels of the twentieth century.

“The person who really wields the power takes no hand in carrying out his directives, while the managers are covered by the fact that they are acting not on their own behalf but as functionaries. You will find such arrangements everywhere these days, and by no means exclusively in the world of finance. This system of indirection elevated to an art is what nowadays enables the individual and society as a whole to function with a clear conscience: the button to be pushed is always clean and shiny, and what happens at the other end of the line is the business of others, who, for their part, don’t press the button. Do you find this revolting? It is how we let thousands die or vegetate, set in motion whole avalanches of suffering, but we always get things done. I might go so far to say that what we’re seeing here, in this form of the social division of labor,

is nothing else than the ancient dualism of conscience between the end that is approved and the means that are tolerated, though here we have it in a grandiose and dangerous form."

What all of the above non-economics references express as social costs of a highly specialized division of labor are different than the private coordination costs of focus in Becker and Murphy (1992), and they are more difficult to manage. Indeed, Arrow (1974, p. 77) suggests this in his observation that "There is much to be done in the design of institutions to reconcile the values of responsibility and authority…". Authority/specialization is needed in organizations in order manage massive flows of information and take decisions in a timely manner; however, institutions must have incentive-compatible mechanisms wherein such authority is held optimally responsible for the consequences of its actions. The collapses of Enron and Arthur Andersen in 2001-2002, the Financial Crisis of 2008, and several high-profile breaches of corporate information security systems in the past decade (e.g., Target, Adobe, Marriott, and Equifax) are just a few examples of the relative fragility of highly specialized systems and of the social consequences when that fragility is disturbed. To state the matter generally: There is a tradeoff between system performance and robustness.[11] Economists tend to focus upon the greater performance that is possible from a more specialized division of labor, and tend not to consider the moral context within which intense specialization is occurring. Whereas, non-economists tend to worry more about the robustness and moral context of operating with greater specialization—for they are concerned not just about system performance but also about the unequal distribution of social consequences that tends to occur when highly specialized systems falter.[12] The argument in this paper—amplifying Thoreau's view but in modern microeconomic language—is that it is not robust to focus only upon first-best economically efficient prescriptions as though there is no model nor parameter uncertainty (in economics-speak) and/or as though there are no other criteria (such as equity) by which non-economists and the median voter will evaluate policy outcomes. Colleagues in disciplines outside of economics and citizens outside of academia altogether can enrich the design of economic policy with diverse perspectives communicated with language that resonates with people outside of the economics profession.

Heading toward a conclusion on this topic of intense specialization of labor, Becker and Murphy (1992, p. 1143) also call our attention to the 'rather enormous literature' regarding the comprehensive division of labor found in insect colonies. This is noteworthy for our evaluation of Thoreau's prescience regarding

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[11] A simple example illustrates this performance-robustness tradeoff. Consider that the speed of a car can usually be increased to achieve greater performance in terms of minimizing the time elapsed going from points A to B. This increase in performance is unambiguously desirable *unless* it is possible that a deer will run in front of one's vehicle. If this is possible—and all drivers/pilots know this to be possible—it is prudent to trade off some performance in terms of miles per hour for some stability. Each mile per hour we reduce our speed buys us a marginally better chance of reacting in time to avoid a collision with a deer.

[12] One notable exception to this generalization is the work of Economics Nobel Laureates Hansen and Sargent; see, e.g., their 2008 Princeton U Press book entitled *Robustness*.

modern microeconomic theory, for Thoreau was and still is widely-regarded as a naturalist and he was certainly interested in analogies between human and insect dynamics.[13] Modern research by evolutionary biologists such as Goldsby *et al.* (2012) and Jeanson (2019) is very much in the spirit that Thoreau, Arrow, Becker and Murphy anticipate. These studies consider the role of task-switching costs and individual flexibility, respectively, in the emergence of various intensities of division of labor in the biological world. Both the pervasiveness of division of labor in natural and human-built domains and the fact that evaluation of its strengths and weaknesses appears in a wide range of disciplinary venues suggests that its appropriate evaluation requires just the multidisciplinary approach Thoreau promoted. The socially optimal degree of division of labor is not likely to be discerned with a high degree of division of labor.

CONCLUSION

This paper began with the proposition that as economists circle back to topics of Thoreau's concern, they could gain important insights from how Thoreau communicated his insights to mass audiences in his time and for the ensuing 160+ years. In particular, Thoreau knew that what we now refer to as 'clubs with entrapment', 'internalities', and 'extreme division of labor' involved impactful spillover effects that free market forces could not be counted upon to rectify and that therefore required public policy attention. While it is unclear that Thoreau would pass the modern microeconomic theory doctoral prelim exam—given the graduate-level mathematics involved—this paper argues that Thoreau certainly had a grasp of some key microeconomic concepts that (1) appear in the top journals and presentation venues in the economics profession (including recognition with Nobel prizes) and (2) reveal indeed to non-economists that contemporary microeconomic theory includes pathways of investigation such as behavioral economics and ecological economics that considerably expand the scope of what they may perceive neoclassical microeconomic analysis to regard. Notwithstanding this healthy broadening of microeconomic theory over time, however, the economics profession struggles to get its efficiency/first-best message out to researchers in other disciplines; to public policy-makers; and to the general public. As Arrow might say, Thoreau has the code. Economists need it. The consequence of this failure to communicate is that not only do first-best economic prescriptions fall out of reach, but as Goulder (2020) emphasizes, second-best outcomes can also be elusive if policy bargaining to implement the first-best drags on for years. Hence, a take-home message of this paper is a reminder that first-best is superior to second-best, and second-best is superior to third-best (i.e., 'business as usual'). This may seem obvious; however, what several of the references in this paper essentially point out—that echoes Thoreau's insight from long ago—is that if economists go for broke in promoting first-best policy proposals that the general public doesn't buy, then politically we may find ourselves at a third-best outcome rather than at second-best. And that is not the preferred solution to our social constrained optimization on any topic.

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[13] See, e.g, Norton (1991) and Costa (2002).

A second goal of this paper is to help bridge understandings between scholars in the humanities and in quantitative microeconomic theory. Humanists like Thoreau and humanists today may strengthen their arguments by incorporating microeconomic analysis. That is to say, it is a position of strength to utilize concepts from our humanities and from our microeconomic analysis as complements rather than to think of these directions of inquiry as substitutes or—worse yet—as competitors. This paper has tried to elucidate several examples wherein leading microeconomic theorists concur with concerns about free market forces raised by humanists. In turn, economists stand a far higher chance of the public grasping the efficiency aspects of decisions if economists talk the talk and walk the walk along the humanities-economic frontier. Thoreau in particular reminds us that some of the key challenges we face are old (if not timeless) and not necessarily driven by 'high tech' of the current age. Rather, the challenges are just as Dixit, Allcott, and Arrow suggest—devising policies and institutions that efficiently balance individual versus social needs and wants, and expressing the choices we have in terms non-economists can understand and trust.

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REFERENCES

Agha, L., Frandsen, B., Rebitzer, J. B. 2019. "Fragmented Division of Labor and Healthcare Costs: Evidence from Moves across Regions." *Journal of Public Economics* 169: 144-159.

Allcott, H.; Lockwood, B. B.; Taubinsky, D. 2019. "Should We Tax Sugar-sweetened Beverages? An Overview of Theory and Evidence." *Journal of Economic Perspectives* 33(3): 202-227.

Arrow, K. 1974. *The Limits to Organization*, New York: Norton.

Becker, C. 2008. "Thoreau's Economic Philosophy." *European Journal of the History of Economic Thought* 15(2): 211-246.

Becker, G., Murphy, K. M. 1992. "The Division of Labor, Coordination Costs, and Knowledge." *Quarterly Journal of Economics* CVII(4): 1137-1160.

Boyer, P., Bang Petersen, M. 2018. "Folk-economic Beliefs: An Evolutionary Cognitive Model." *Behavioral and Brain Sciences* 41: 1-65.

Campbell, J. Y. 2016. "Restoring Rational Choice: The Challenge of Consumer Financial Regulation." *American Economic Review Papers & Proceedings* (Ely Lecture) 106(5): 1-30.

Chetty, R. 2015. "Behavioral Economics and Public Policy: A Pragmatic Perspective." *American Economic Review Papers & Proceedings* (Ely Lecture) 105(5): 1-33.

Costa, J. T. 2002. "Scale Models? What Insect Societies Teach Us About Ourselves." *Proceedings of the American Philosophical Society* 146(2): 170-180.

Coviello, D., Ichino, A., Persico, N. 2019. "Measuring the Gains from Labor Specialization." *Journal of Law & Economics* 62(3): 403-426.

David, P. 1985. "Clio and the Economics of QWERTY." *American Economic Review Papers & Proceedings* 75(2): 332-337.

Dixit, A. 2003. "Clubs with Entrapment." *American Economic Review* 93(5): 1824-1829.

Frank, R. H. 2008. "Should Public Policy Respond to Positional Externalities?" *Journal of Public Economics* 92 (8-9): 1777-1786.

Fusfeld, D. R. 1973. "Types of Radicalism in American Economics." *American Economic Review Papers & Proceedings* 63(2): 145-151.

Gilmore, M. T. 1985. *American Romanticism and the Marketplace*. Chicago: University of Chicago Press.

Goldsby, H. J., Dornhaus, A., Kerr, B., Ofria, C. 2012. "Task-switching Costs Promote the Evolution of Division of Labor and Shifts in Individuality." *Proceedings of the National Academy of Sciences* 109 (34): 13686-13691.

Goulder, L. H. 2020. "Timing Is Everything: How Economists Can Better Address the Urgency of Stronger Climate Policy." *Review of Environmental Economics and Policy* 14(1): 143-156.

Haferkamp, A., Fetchenhauer, D., Belschak, F., Enste, D. 2009. "Efficiency versus Fairness: The Evaluation of Labor Market Policies by Economists and Laypeople." *Journal of Economic Psychology* 30: 527-539.

Heal, G., Kunreuther, H. 2010. "Social Reinforcement: Cascades, Entrapment and Tipping." *American Economic Journal: Microeconomics* 2(1): 86-99.

Howarth, W. 2017. "Reading Thoreau at 200." *American Scholar*, June 5, 2017, https://theamericanscholar.org/reading-thoreau-at-200/#.X06UOshKjIU. Last accessed 5/23/21.

Jeanson, R. 2019. "Within-individual Behavioral Variability and Division of Labour in Social Insects*.*" *Journal of Experimental Biology* 222: 1-8.

Malueg. D. A., Yates, A. J. 2006. "Citizen Participation in Pollution Permit Markets." *Journal of Environmental Economics and Management* 51(2): 205-217.

Morton, F. 1995. "Legendary Novel of the Past, Recaptured." Review of Robert Musil's *The Man Without Qualities*, in *The Wall Street Journal*, April 12, 1995, A12.

Musil, R. 1930. *The Man Without Qualities*. Translated by S. Wilkins and B. Pike, New York: Knopf, 1995.

Norton, B. G. 1991. "Thoreau's Insect Analogies, or, Why Environmentalists Hate Mainstream Economists." *Environmental Ethics* 13(3): 235-251.

Nyborg, K., Howarth, R. B., Brekke, K. A. 2006. "Green Consumers and Public Policy: On Socially Contingent Moral Motivation." *Resource and Energy Economics* 28(4): 351-366.

Rubin, P. H. 2003. "Folk Economics." *Southern Economic Journal* 70(1): 157-171.

Sattelmeyer, R. 1988. *Thoreau's Reading: A Study in Intellectual History with Bibliographical Catalogue*, Princeton, NJ: Princeton University Press.

Sattelmeyer, R. 2007. "Walden: Climbing the Canon." In *More Day to Dawn: Thoreau's Walden for the Twenty-first Century*, edited by S. H. Petrulionis and L. D. Walls, University of Massachusetts Press.

Schmalensee, R., Stavins, R. N. 2017. "Lessons Learned from Three Decades of Experience with Cap and Trade." *Review of Environmental Economics and Policy* 11(1): 59-79.

Shaffer, B. 2020. "Misunderstanding Nonlinear Prices: Evidence from a Natural Experiment on Residential Energy Demand." *American Economic Journal: Economic Policy* 12(3): 433-61.

Smith, A. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*, reprint edited by R. H. Campbell and A. S. Skinner, Indianapolis: Liberty Press, 1981.

Thoreau, H. D. 1854. *Walden*, reprint, Philadelphia: Running Press, 1990.

Wagner, J. 2004. "Free Riding on Eiseley's Star Thrower, Thoreau's Huckleberry Patch, and Havel's Streetcar in the Local and Global Commons." *Interdisciplinary Studies in Literature and Environment* 11(1): 101-119.

Wagner, J. 2013. "American Georgics and Globalization: Literary and Economic Co-evolution in Three Enclosure Movements." *Interdisciplinary Studies in Literature and Environment* 20(1): 71-84.

Wagner, J. 2017. "Humanities as Technology in Teaching Economics." *International Review of Economics Education* 25: 35-40.

Walker, B. 1998. "Thoreau's Alternative Economics: Work, Liberty and Democratic Cultivation." *The American Political Science Review* 92(4): 845-856.

Walls, L. D. 2017. *Henry David Thoreau: A Life*, Chicago: University of Chicago Press.
Watts, M., Smith, R. F. 1989. "Economics in Literature and Drama." *Journal of Economic Education* 20(3): 291-307.

Wasserman, M. F., Slack, J. D. 2021. "Is Too Much Specialization a Bad Thing? Specialization in Specialized Courts." *Northwestern University Law Review* 115(5): 1405-1504.

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