Manufacturing & Service Operations Management

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

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To cite this article:
Sridhar Tayur (2017) OM Forum—An Essay on Operations Management. Manufacturing & Service Operations Management 19(4):526-533. https://doi.org/10.1287/msom.2017.0665

http://pubsonline.informs.org/journal/msom/

MANUFACTURING & SERVICE OPERATIONS MANAGEMENT
Vol. 19, No. 4, Fall 2017, pp. 526–533
ISSN 1523-4614 (print), ISSN 1526-5498 (online)

OM Forum

An Essay on Operations Management

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Received: March 22, 2017
Revised: May 9, 2017; June 15, 2017
Accepted: June 28, 2017
Published Online in Articles in Advance: September 22, 2017

https://doi.org/10.1287/msom.2017.0665

Abstract. I have enjoyed the opportunities to identify new problems, implement my ideas and algorithms in practice, work closely with start-ups and mature organizations, and build a software company that created the market for enterprise inventory optimization, while also developing novel solution methods that have adapted and enhanced esoteric mathematics. This invited essay is a playful reflection of creative joy in operations management (OM)—obtained by intertwining theoretical developments with industrial implementations forging a path that consciously forks from received wisdom and conventional methods—while looking ahead to continued delights.

Keywords: sample path methods • algebraic geometry • supply chain management • organ transplantation • queuing games

1. The Importance of Being Playful

> The mass of men lead lives of quiet desperation.... There is no play in them.... A man who has at length found something to do will not need a new suit to do it in.... I am convinced that to maintain one's self on this earth is not a hardship but a pastime.
>
> —Henry David Thoreau (2004, pp. 6, 17, 53)

Operations management (OM)—through research, industrial implementation, software entrepreneurship, investing in start-ups and turnarounds, and creating a social enterprise—has provided me with that playground to accomplish the trifecta: (a) reveling in *intellectual enjoyment* of elegant mathematics and clever algorithms, (b) contributing to economic vibrancy, and (c) improving and saving lives. These enjoyable activities have been performed in close collaboration with MBA and Ph.D. students, academic colleagues, and SmartOps' employees (and partners), and by building long-term relationships with industry executives.

I readily admit that I did not, at the outset, plan for (or envision the possibility of) such a fulfilling experience. Being ignorant of how the world actually works and the many urgent needs of our society, my preoccupations then were largely confined to mathematical analysis of make-believe models. I grew beyond this stage of intellectual immaturity (less rapidly than I would have liked) as I recognized that (1) OM could be a channel for something of great value, (2) technique without application is barren, (3) to know what problem to study is quite as important as (if not more than) developing the solution to it, and (4) a prelude to the analytical intellect is a part of mind where imagination resides, and one should allow the intellect to lie fallow. (Perhaps imagination is more important than knowledge!) I took the road less traveled—which has indeed made all the difference—by putting the intimate fusion of theory with practice at the center of my scheme, by participating in the new forces (such as information technology, globalization, and venture capital (VC)-infused software entrepreneurship) that have made our world so different, and by distancing myself, repeatedly, from the mechanical imitations of inherited habits in favor of pursuing newness.

In this invited article, on the occasion of being made a distinguished fellow of the Manufacturing and Service Operations Management Society, I want to

(1) celebrate the splendor of various mathematical techniques, ranging from algebraic geometry to queuing games, from sample path methods and infinitesimal perturbation analysis (IPA) to Schur convexity, and from computational mathematical programming and constraint programming (CP) to machine learning (ML); and

(2) delight on a variety of practical applications and efficient monetizing methods, ranging from responsive supply chain design to private jet scheduling, from supply chain flexibility to executing on multimillion dollar gain-sharing and revenue-sharing contracts, from managing product variety through postponement to managing factories effectively, from venture-capital-based start-ups in online fashion rentals to two-sided platforms, and from dynamic scheduling of video game advertisements to facilitating multiple listing for organ transplantation.

Tables 1–3 provide lists of my research, highlighting topics, techniques, and industry partners. I have previously discussed OM teaching in business schools (Tayur 2016) and so will not discuss it here. I have deliberately chosen those examples (about a dozen, italicized in the tables) that emphasize departures from

Table 1. Academic Pursuits Primarily for Intellectual Enjoyment and Knowledge Creation

Novel algorithms for	Mathematical techniques
Chance-constrained programming	Rapidly mixing Markov chains, random walks, conductance, spectral gap
Integer programming	*Algebraic geometry, Grobner basis, Hilbert Nullstellensatz*
Chance-constrained integer programming	Test sets, Grobner basis
Bipartite and multipartite graphs	Complexity theory, randomized approximation algorithms
Stochastic inventory models	*Infinitesimal perturbation analysis*
Discrete-time production–inventory model enhancements	
Limited historical data	Johnson-type distributions
Capacity constraint	Dam models, Volterra integrals
Multiple products sharing capacity	Stochastic economic lot scheduling problem, IPA
Nonstationary demand: Cyclic	Stochastic dynamic programming (SDP), IPA
Nonstationary demand: Mean reverting	SDP, IPA
Multistage	Method of Loynes, IPA, large deviation approximation
Reentrant flow	Stability, IPA
Strategic behavior in global supply chains	
Combating strategic counterfeiters	Game theory
Combating child labor	Principal–agent model

Note. Examples in italics emphasize departures from conventional topics, well-treaded mathematical methods, and commonplace methods of monetizing value.

conventional topics, well-treaded mathematical methods, and commonplace methods of monetizing value. This opportunity has allowed me to synthesize my research and industrial implementations, even if of a limited range, in one simple mosaic. It is my modest hope that this essai will entertain and enlighten its readers into the infinite possibilities of OM.

2. An Academic Capitalist View of Life

2.1. The Path Taken

> If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music which he hears.
>
> —Thoreau (2004, p. 263)

The first point of departure in my study of stochastic production inventory models—different from the conventional approach that more or less imitates the one developed by Arrow, Karlin, and Scarf—is my focus on finding a general purpose computational method that can be broadly applied to tackle problems that arise in practice: infinitesimal perturbation analysis. This relies on sample path derivatives being consistent, and they indeed are in a very wide variety of situations, including those with multiple stages (including reentrant flows), with multiple products (that share capacity), with networks of locations that allow transshipments, and even when faced with two-stage programs that involve solving a linear program as recourse. IPA can work directly from data rather than starting with assumptions of probability distributions, in continuous time models or in discrete time, along finite and infinite horizons and in stationary and nonstationary settings. When faced with discontinuous situations, a smoothing procedure can usually be applied, thus making this method versatile. It is also very quick on problems of industrial scale.

Several papers reframe inventory models and develop IPA (Tayur 1993a, Glasserman and Tayur 1995, Anupindi and Tayur 1998) and use it to solve actual industry problems, such as developing a rapid-response supply chain at Caterpillar (Rao et al. 2000) and designing vanilla boxes at IBM (Swaminathan and Tayur 1998). See Tables 1 and 2. More details on IPA development and these applications can be found in one of my previous invited articles (Tayur 2013).

I have found sample path methods to be very powerful computationally and, additionally, often able to provide underlying structural results with few restrictive assumptions in a wide variety of applications, ranging from serial production lines operated using kanbans (Tayur 1993b) to online fashion rentals (Slaugh et al. 2016). I have found it fruitful to combine these methods with the (very beautiful) framework of Schur convexity, which has also been useful in settings that may not involve sample path methods; for example, in multiple listing for organ transplants, modeled as a selfish-routing game on a network of overcrowded queues with abandonment (Ata et al. 2017) studied using fluid and diffusion models.

2.2. A Tale of Two Grobner Bases

My second point of departure—diverging from conventional methods to solve integer programs (IPs) that usually begin with linear programming relaxation—was to study IPs using algebraic geometry. This approach does not rely on linear programming relaxations or convex hull representations or interior point methods, but is based on an entirely different reframing of the problem. I have studied IPs in two entirely different ways within algebraic geometry by reframing IPs as two very different types of polynomial ideals and then interpreting the Grobner bases of those ideals appropriately.

In the first case, in Tayur et al. (1995), there is a geometric interpretation that lends itself to treating the Grobner basis as a test set. Indeed, this is the minimal test set possible, and elegantly generalizes earlier work. Beyond solving IPs, this method—the first, and still the only one to date—is particularly well suited to solving chance-constrained integer programs, or stochastic

Table 2. Academic Capitalist: Solving Practical Problems and Monetizing As Consultant, Entrepreneur, or Investor

New business models	Company	Quantitative methods
Time-shared jet aircraft	*Raytheon, Flight Options*	*Mixed-integer linear programming (MILP)*
Dynamic scheduling of video games	Massive Incorporated, Microsoft	Stochastic MILP
Online fashion rentals	*Rent the Runway*	*Sample path coupling, Schur convexity*
Daily pricing and personalized products for fitness studios	Zenrez	Proprietary ML algorithms
Core operations management problems in Fortune 500/Global 2000 product companies		
Responsive supply chains	*Caterpillar*	*IPA*
Flexible supply chains	*Deere*	*MILP, inventory models*
Product portfolio optimization	Deere	MILP, CP, consumer choice models
Managing variety through postponement	Caterpillar	Stochastic program with recourse, IPA
Bundling, pricing, and lane strategy	Caterpillar	Econometrics, MILP
Lead time quotation	GE	Dynamic programming, adaptive adversary and competitive analysis
Capacity planning	GE	IPA
Production planning	ConAgra	MILP
Multiechelon inventory optimization and sales and operations planning	*100+companies through SmartOps Corporation*	*Proprietary algorithm*
Lean operations: kanbans and JIT	*GE, CCG Inc.*	*Queuing, sample path methods, GSMP, and antimatroids*
Procurement: Net landed cost	Grocery retailers	Inventory models and nonlinear programming
Omnichannel fulfillment	Several consumer packaged goods (CPG) and retailers through Orchestro, Onera Other supply chain issues	Proprietary algorithms based on machine learning, IPA
Multienterprise coordination	*Deere*	*Proprietary algorithms*
Value of information	CPG and retail: North Side Foods and McDonald's	Dynamic programming, IPA
Quantity Discounts	CPG and retail: Heinz and Target	Dynamic programming
Exchange rates; quantity flexibility	Caterpillar's Asian suppliers	Stochastic inventory models
Real (capacity) options	Semiconductor industry	Game theory; stochastic models

Note. Examples in italics emphasize departures from conventional topics, well-treaded mathematical methods, and commonplace methods of monetizing value.

integer programs with random right-hand sides. In the second framing, in Bertsimas et al. (2000), the elements of the Grobner basis correspond to all feasible solutions of the IP, and so (applying Hilbert's Nullstellensatz) we get to characterize weak duality for integer programming! This is Farkas' lemma for IP.

2.3. In Praise of Newness

> The market is supply and demand. Seen as statics, it is a gravitational field that produces equilibrium price as if guided by an omniscient auctioneer. Seen as dynamics, it is a voyage of discovery that, powered by profit or driven on by challenge, need never arrive at its final point of rest . . . . Newness is the leitmotiv. Capitalism is newness. —David Reisman (2004, pp. 1, 4, 72)

My third point of departure was to start working closely with entrepreneurial ventures, in addition to mature organizations (consulting firms like McKinsey or Fortune 500 firms). In 1994, I had the wonderful opportunity to work with a start-up—a division of Raytheon, acquired by Flight Options—that pioneered the (now mature) business model of time-shared jet aircraft (Keskinocak and Tayur 1998). In 2007, it was an absolute pleasure to work with Massive Incorporated (acquired by Microsoft), which pioneered the dynamic placement of advertisements in video games (Turner et al. 2011). In 2011, a pioneer in online fashion rentals (Rent the Runway) provided me with an opportunity to revisit inventory models, accounting for usage-based loss (Slaugh et al. 2016). See Table 2.

I am working closely with several other start-ups, including Onera Commerce (where I am an investor, alongside Bain Capital), in the area of omnichannel fulfillment, and ZenRez (where I am additionally an advisor), a two-sided platform that connects millennial consumers to fitness studios through optimized daily pricing and personalized product bundles. Both start-ups use proprietary algorithms based on machine learning.

To be able to work so directly in the very engine of not just economic growth but the creation of ideas, knowledge, goods, and opportunities in our capitalist society—newness brought to the market via start-ups—through OM is exciting and intellectually rewarding. Beyond the above two start-ups, where I

Table 3. Social Welfare and Market Design

Healthcare operations	Methods	Partner
Overtesting	Queuing games	UPMC
Personalized medicine: Warfarin dosage	Randomized control trial	AGH
Personalized cancer therapy	*Machine learning*	*Mitra Biotech*
Organ transplantation: Multiple listing	*Queuing games, selfish routing, overcrowded queues, fluid models*	*MGH, UPMC, Wisconsin, UCSF*
Organ transplantation: Increasing supply	*Behavioral "nudge" videos, RCT*	*NJ, NV, GA OPOs*
Organ transplantation: Fair allocation	Markov chains, simulation	MGH
Organ transplantation: Policy evaluation	Queuing models, Lyapunov methods, matrix geometric methods	UCSF, MGH
Nursing homes: Consistency of care	Probabilistic analysis, Schur convexity	Passavant, Vincentian

Notes. Examples in italics emphasize departures from conventional topics, well-treaded mathematical methods, and commonplace methods of monetizing value. UPMC, University of Pittsburgh Medical Center; AGH, Allegheny General Hospital; MGH, Massachusetts General Hospital; UCSF, University of California at San Francisco Transplant Center; NJ, New Jersey; GA, Georgia; NV, Nevada.

am an angel investor, I am also a limited partner (and advisor)—a fourth point of departure—in a venture capital fund, Neotribe Ventures, where we expect to make 20–25 early-stage investments into start-ups over the next two to three years.

2.4. The Fulfillment of Dreams

The beginning of the twenty-first century, I would expect, will be recognized in history as an era when algorithms and software entrepreneurship changed the world. It is the zeitgeist of our times. As fifth and sixth points of departure, I founded and served as chief executive officer (CEO; not chief technology officer or chief science officer) of SmartOps Corporation, an enterprise software company—not a consulting firm or a company that creates low-cost desktop tools for consultants—and created the market for enterprise inventory optimization (EIO), keeping in mind Thoreau's recommendation:

> if one advances confidently in the directions of his dreams, and endeavors to live the life which he has imagined, he will meet success unexpected in common hours. (Thoreau 2004, p. 262)

Details about SmartOps can be found in a Darden case (now distributed by Harvard Business School; Wilcox and Yemen 2011). Briefly, SmartOps (a) was founded in 2000 with angel capital from McKinsey directors, Goldman partners, and other successful entrepreneurs and VC funding; (b) was profitable by 2003; (c) had revenue growth every year since its founding; (d) pioneered a new sales method called proof-of-value, where company supply chain data would be run on EIO software and compared with existing inventory parameters (thus illustrating value possible through "fix the mix"); and (e) executed a partnership with SAP, beginning with an endorsed business solution, a comarketing contract, and followed by a solution extension ("Sol-Ex," where SAP resells SmartOps EIO). Over 100 Fortune 500/Global 2000 companies bought our software, exceeding over $250 million in sales across several industry verticals—chemicals, consumer packaged goods, high-tech, industrial machinery, medical devices, pharmaceuticals—in dozens of countries around the world. SAP acquired us (in 2013), and since then, dozens of other companies in several additional countries (including Russia and China) have incorporated EIO into their ongoing supply chain planning. Connecting enterprise resource planning to advanced planning and scheduling, EIO provides the *prescriptive analytics* on which hundreds of billions of dollars of commerce in global supply chains operate today.

2.5. The Sharing Contract

Will Rogers famously remarked, "It ain't bragging if it's true." This is a seventh point of departure: the truth about how I monetized our OM skills, different from fixed price or time (and material) contracts. It is intricately related to having built trust with the customer, based on successful collaboration on earlier projects.

I am a big believer in long-term relationships with companies: including Caterpillar, McKinsey, Deere, Kellogg's, and ConAgra (Table 2). These multiyear relationships enabled me to execute under a entirely new type of contract. Specifically, at Deere we designed a flexible supply chain that depended on the season: in the "on-season," April–September, the distribution network, logistics strategy, and forward inventory placement were different from in the off-season (Tardif et al. 2010). This in itself was a new approach to designing supply chain flexibility for Deere. What was additionally different was that this work was conducted through a gain-sharing contract between Deere and SmartOps, where we split the benefits 50–50 (on a $10 million incremental increased cash flow), netting us $5 million over a period of about two and half years. While performance-based contracts are not uncommon with either bonus or "at-risk" payment clauses, this equal sharing of gains is exceptionally rare, even unheard of from what I gathered at that time. This relationship was particularly helpful in growing SmartOps—expanding into Europe—without diluting

our investors (or employee stock option pool) as it avoided additional equity offering or debt financing.

2.6. Management Mechanics

A lot of recent academic literature has discussed decentralized supply chains (and supply chain contracts), but has been pretty sparse on the actual multienterprise implementation of our supply chain ideas. An eighth point of departure is when we created an incentive scheme for 2,500+ independent dealers of Deere to implement—into their weekly ongoing automated operations—the recommended stocking levels computed by a centralized two-stage model using SmartOps EIO software (Troyer et al. 2005). This reduced (or avoided the growth of) the inventories in the supply chain by over $1 billion in four years while increasing service levels. No game theoretic models were used here or in the gain-sharing contract of the previous section. That does not mean that incentives and self-serving behavior are to be ignored in the real world. Rather, what I am saying is that embedding a "fixed-point" solution in the mathematical model is not necessary. Indeed, what was likely helpful to implementing our recommendations in practice, and monetizing them, was "management mechanics," described in more detail in Tayur (2013), which includes the following steps: (a) pilot it with small group to iron out executional issues, (b) allow clients not to use the recommendations for some time or make changes only partway from current operations, (c) finance them to implement the recommendations, and (d) provide "what-if" analyses to create comfort and intuition by varying various inputs and outputs. This approach has worked repeatedly to implement improved supply chain solutions that required "buy-in" from various stakeholders.

This is not to say game theory is not useful as a tool for analysis; indeed, I have used it in a supply chain context to better understand how to combat strategic counterfeiters (Cho et al. 2015) and in healthcare operations to understand overtesting (Dai et al. 2017). See Tables 1 and 3. The point I am trying to emphasize here is that game theory mathematics explicitly identifying an "equilibrium" through fixed-point computations are not necessary in implementation, or for understanding and designing good contracts that companies can actually use, even in these typical multienterprise contexts. It is not that firms or actors are not strategic, but that there is an alternative to hyperstylized models with imbedded fixed-point calculations as a tool for study.

Another example of multienterprise interaction is in Altintas et al. (2008), where we helped design a quantity discount schedule for a consumer package goods manufacturer (such as Heinz) for use with retailers such as Target. An interesting managerial insight that we found in this analysis is what we term as the "reverse bullwhip effect." As end-consumer (independent) demand variance goes down at the retailer, the lumpiness of orders (dependent demand) from the retailer to the manufacturer can go up, as the retailer optimizes for quantity discounts, based on the schedule created by the manufacturer, by either delaying an order ("wait and see") or prepurchasing ("buy and hold") for future demand. We were able to derive this insight by studying how the retailer behaves as the manufacturer changes the discount schedule through scenario analysis of a rich enough model, and not by equilibrium computations of ever-more-stylized models that typically cannot capture important operational features. There are other such examples; see Gavirneni et al. (1999).

2.7. The Brahmin Ethic and the Spirit of Capitalism

In the late 1980s, at the time I was in my Ph.D. program at Cornell, there was considerable interest in understanding Japanese manufacturing techniques, including the just-in-time (JIT) philosophy and kanban-controlled manufacturing systems. This provided me with an opportunity to study serial production lines that operate using kanbans using methods different from Markovian models, using sample path methods and Schur convexity that I mentioned earlier (Tayur 1993b), and, even more enjoyably, by studying the underlying generalized semi-Markov process (GSMP) by counting the number of events, keeping score if you will, of departures. It turns out (Tayur 1992)—even deeper than what can be penetrated through sample path methods and stochastic comparisons, which themselves vastly exceed what Markovian analyses can do—that these scores form an antimatroid that reveals the fundamental structure of these systems: reversibility, monotonicity, and concavity in very general settings without the tedious construction of sample path coupling.

At this time, I was still at the stage of intellectual immaturity where the pursuit of elegant model analyses through ever more esoteric mathematics was all that I could see as the world in front of me. In 1991, I had an exciting opportunity—a very fortunate involvement in retrospect—to implement a kanban system at GE, as part of an overall plant management overhaul that included product line rationalization, stochastic economic lot scheduling, quality control, capacity planning, and lead time quotation (Tayur 2000). Beyond the dramatically improved business metrics achieved at the factory that essentially prevented it from being shut down, saving over 300 manufacturing jobs in a small town in Ohio, the result was a drastic shift in my career path, as the realization dawned on me that OM can make a difference in our society, triggering a shift from a near-complete focus on esoteric

mathematical analysis of make-believe models, gradually at first to relatively straightforward consulting projects that required implementation (like scheduling of time-shared aircraft), then to software entrepreneurship, and finally to investing into start-ups and in turnaround situations. This project perhaps marks the beginning of the metamorphosis from a bona fide academic pursuing "Brahmin research"—so pure and chaste that it did not and, even more importantly, could not have any practical applications—to becoming the "academic capitalist" that I am today.

Many years later, this hands-on experience at GE came to further fruitful use as two of my MBA students founded Commonwealth Capital Group (CCG), a private equity (PE) start-up (in which I was a limited partner and on the advisory board) that focused on turning around small manufacturing firms in Pennsylvania struggling with Chinese imports in a global trade war. This is the ninth point of departure: putting money alongside PE firms. This fund did very well: its internal rate of return was over 21%, placing it in the top quartile of PE funds of its vintage, while rebuilding these manufacturing firms. For example, Hodge Foundry, which was struggling as a supplier to auto manufacturers, was recast (pun intended) as a supplier to the wind industry: its revenues quadrupled and employment doubled as its earnings flipped from negative to strongly positive. The return on our investment was more than 11-fold (in under seven years).

As I mentioned earlier, it is exciting to be so directly involved in our society's well-being through OM supporting economic vibrancy and creativity: our skills can be applied to making large companies (public or private) more efficient, creating shareholder value (either directly or through consulting firms); we can work through start-ups and VC firms; and we can help small firms by combining our expertise with our capital invested through PE firms.

3. The Practice of the Leisure Class

The following is from Bertrand Russell's *In Praise of Idleness* (1935, p. 18): "the wise use of leisure is a product of civilization and education with a view of mental enjoyment as well as to the direct usefulness of technical knowledge."

After my decade as CEO of SmartOps, with its postacquisition life secure and thriving within SAP as part of integrated business planning, I decided to look for new opportunities, this time in healthcare operations. By then, I had recognized that I was fortunate to possess qualities—at least in some measure—our society just so happens to prize: mathematical ability, entrepreneurial energy, and a fertile imagination. Not to mention a social and professional network of influential people and sufficient personal wealth to pursue semiphilanthropic initiatives. It was time to put these qualities to work toward solving problems of society that were not being adequately addressed by market capitalism. Not having "to depend on these pursuits for my livelihood," as Russell (1935, p. 25) predicted, my "originality would be unhampered as there would be no need to conform to the standards set by elderly pundits."

3.1. An Operationalization of Justice

One initiative that combines mental enjoyment and technical knowledge is OrganJet, which saves lives through affordable on-demand and timely access to transplantation. There is significant geographic disparity in deceased donor organ transplantation in the United States (across 58 different donor service areas grouped into 11 regions). Vigorous attempts for broader sharing of organs across regions and redistricting to better match supply and demand had not made much progress for years, and this problem appeared to be an intractable one. As luck would have it, my earlier work on time-shared jets and the fact that as CEO of SmartOps I was a NetJets customer (had a time-share on a private jet) led to my idea (in the blink of an eye): my solution to this apparent intractability was to "democratize" Steve Jobs, who multiple listed in several places across the country, and when an organ became available in, say, Tennessee, reached that transplant center (from his home in Palo Alto) within a few hours using his personal private jet.

As a tenth point of departure, I created a social enterprise to help people learn about multiple listing, and also to get there in an affordable manner when needed. This on-demand affordability is practically possible because there are over 18,000 jets whose average utilization is less than 50%, and these jet providers are eager to participate in the spot market, especially for such a life-altering cause. What would happen if this became widespread? We modeled each transplant center as an overcrowded queue with abandonment and then studied the issue as a selfish routing game on a network of such queues (Ata et al. 2017). This work, an example of queuing games as it combines game theory and queuing models, shows that disparity reduces significantly, more transplants are possible, and the worst off will improve. This is a Rawlsian solution, in operation since 2011, decreasing the longest wait times while increasing the number of transplants. Variously called "imaginative," "a genius idea," and "disruptive," OrganJet has attracted attention from media, Nobel laureates, and private insurance companies, and gained support from bioethicists who were previously concerned that multiple listing would be limited to the ultrawealthy. Additionally, I created a GuardianWings program that allows for some cross-subsidy to those who may not be able to fully afford the costs. There is a Harvard Business case on OrganJet and GuardianWings as well (Battilana and Weber 2013).

3.2. The Health of Nations

Beyond OrganJet, as a result of another happy force of imagination, I have begun several randomized control trials (RCTs) at organ procurement organizations (OPOs) to increase next-of-kin consent rate using *nudge videos*, a behavioral approach, to increase the supply of organs and tissues: this initiative garnered me an invitation to President Obama's White House Summit on Organ Donation in 2016, highlighted as one of the top innovations in organ donation. This is very different from other work being done to increase first-person consent, for example, in the Department of Motor Vehicles by framing the consent differently, or attempting to create chains and cycles in living donation (through kidney exchanges). There is now interest in this approach outside the United States, notably in Japan and South Korea.

Other initiatives (see Table 3) in deceased donor transplantation market design include revisiting conditions of participation that could reduce organ discards, helping to compute fairer (and more efficient) exception points in liver allocation, and reengineering the process of organ offers in place today to make it more effective. I have recognized the moral limits of markets and know that capitalism, as dictated by prices and return on investment alone, is insufficient to help in the lives of many in our society. Applying our OM skills to design and operate markets to be more efficient and inclusive has been very fulfilling.

4. A Road to Freedom

In summary, following Yogi Berra, whenever I came to a fork, I took it! So as to not leave the readers with the wrong impression that for-profit start-ups cannot provide life-saving medicine, or that I have become way too spiritual to enjoy monetizing anymore: I am on the advisory board of Mitra Biotech, funded by Accel Partners, and we are applying machine learning algorithms to help create personalized cancer therapies.

"Leisure, luxury, and the pursuit of newness" has been my mantra for what constitutes a "life of liberty," and OM has allowed me to operate in the intersection of math, money, and morals. It is in the belief that many colleagues who wish to make an impact on practice—who hope that their final harvest will not just be a sheaf of mathematical formulae—could benefit from my experience and observations that I have written this essay, offering examples that depart from the mainstream, encouraging them to forge their own path. I hope that my cheerful insouciance—an untainted and joyous celebration of our kaleidoscopic choices—while hopping seamlessly from frivolous video games to life-saving organ transplants, has not concealed my conviction that OM can be a channel for creating significant value in our society while retaining the aesthetic sensibilities that we academics value so much. Let me close with an excerpt (Thoreau 2004, pp. 70, 86, 267–268):

> Why should we live with such hurry and waste of life? . . . Follow your genius closely enough, and it will not fail to show you fresh prospect every hour . . . . Every nail driven should be as another rivet in the machine of the universe, you carrying on the work . . . . There is an incessant influx of novelty into the world.

Acknowledgments

The author would like to thank Tinglong Dai, Alan Scheller-Wolf, and Zach Leung for their careful reading. The titles—of the article and the various sections—pay homage to authors who have entertained and enlightened me: Michel de Montaigne, Oscar Wilde, S. Radhakrishnan, Robert Frost, Charles Dickens, Bertrand Russell, Sigmund Freud, Jean-Jacques Rousseau, Pierre-Simon Laplace, Max Weber, Thorstein Veblen, John Rawls, Adam Smith, and F. A. Hayek. Many of the phrases used throughout this article should be likewise recognizable as straightforward modifications from the pages of these and other similarly gifted writers such as S. Chandrasekhar, David Hume, Thomas Jefferson, and James Jeans.

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