

# LI YANG

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## EDUCATION

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Rice University, PhD, Marketing	2020
Inria, Postdoc, Applied Math	2015
Michigan State University, PhD, Applied Math	2012
National University of Singapore, Master, Applied Math	2006
Sichuan University, Bachelor, Computer Science	2002

## RESEARCH

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<b>Marketing</b>	Analytical Modeling (Pricing, Dynamical Mechanism Design) Empirical Analysis ()
<b>Mathematics</b>	Dynamical System, PDE, Stochastic PDE

## PUBLICATION

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### Working Papers

- “Heterogeneous Value Uncertainty in Online Channels: Dynamic Mechanism Design of Price and Return Policies”, with K. Sudhir, Amit Pazgal.
- “Pricing with Valuation Uncertainty using Dynamic Mechanism Design”, with K. Sudhir, Amit Pazgal.
- “The Effect of Switching Costs on The Competition Between Local and Online Firms”, with Amit Pazgal.

### Ongoing Projects

- “Price Adjustment Policy with Partial Refunds in a Channel”, with Amit Pazgal, Dinah Cohen-Vernik.

### Articles in Math

- “Convergence of the Spectral Galerkin Method for the Stochastic Reaction-Diffusion-Advection Equation”, with Yanzhi Zhang, *Journal of Mathematical Analysis and Applications*, 446(2): 1230-1254, 2017.
- “The Existence of Homoclinic Solution of the Functionalized Cahn-Hilliard Equation”, with Keith Promislow, *SIAM Applied Dynamical System*, 13(2):629-657, 2014.
- “Curvature Driven Flow of Bi-Layer Interfaces”, with Keith Promislow, Nir Gavish, Gurgen Hayrapetyan, *Physica D: Nonlinear Phenomena*, 240(7):675-693, 2010.
- “Efficient and Accurate Numerical Methods for the Klein-Gordon-Schroedinger Equations”, with Bao Weizhu, *Journal of Computational Physics*, 225(2):1863-1893, 2007.

## HONORS

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Jones Business School’s Fellowship	2015-2019
Michigan Center for Industrial and Applied Mathematics (MCIAM) Fellowship	2012
Senior Graduate Teaching Award	2011
Dr. Paul&Wilma Dressel Endowed Scholarship	2010
National University of Singapore Fellowship	2004-2006

## TEACHING

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### Teaching Interests

Principles of Marketing  
Marketing Analytics  
Data Analytics  
Marketing Research

### Courses Taught

Operations Management (Teaching Assistant)  
College Algebra  
Calculus I, II, III  
Differential Equations

## REFERENCES

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### **K. Sudhir**

James L. Frank Professor of Private Enterprise and Management  
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### **Amit Pazgal**

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### **Dinah Cohen-Vernik**

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### “Dynamic Mechanism Design of Price and Return Policies”

**Chair:** Amit Pazgal

**Committee:** K. Sudhir, Dinah Cohen-Vernik, Thomas Hemmer, Vivian Ho

Consumers often don't know their exact valuations about the product before their purchase. After purchasing and using the product, they know their true valuations and then decide whether to keep the product or return it back to the seller with a refund. My dissertation work is mainly focused on how to help the managers to design the optimal price paths (price path: the product price and the refund) for different consumer segments.

In the first essay, “**Heterogeneous Value Uncertainty in Online Channels: Dynamic Mechanism Design of Price and Return Policies**”, I model the channel where the manufacturer as the leader choosing wholesale price and refund terms and the retailer as the follower offering the price paths for two consumer segments. These two consumer segments account for the heterogeneity of consumer market and one is dominated by the other in the mean-preserving spread fashion, i.e., both have the same mean and one (H segment) has a larger variance than the other (L segment). Since consumers choose the price path and decide whether to return the product at the different time periods then it is a sequential screening problem and I choose a framework based on dynamical mechanism design to model it. First, I analyze the base model where the retailer gets no refund for the returned items and I find that there is no discrimination on price paths where the product price is the same as the mean of consumer valuation and no consumer refund is allowed. Second, I examine the model where the manufacturer can optimally choose the refund price for the returned items sent back by the retailer. I find that the discrimination on price paths does exist and both the manufacturer's and the retailer's profits are higher than the base model. This result demonstrates that the partial refund is in fact the key factor resulting in the discrimination on the price paths. It's also interesting to find that the manufacturer's profit is strictly higher than if consumers know their valuations initially. It implies that the sellers can make full use of the consumer uncertainty to earn more profit and the more consumer uncertainty is the more profit the sellers can gain. I also find that the channel's double marginalization induces downward price pressure and upward quantity pressure on the sold products, which is exactly opposite to the findings in the classic channel. Furthermore, the optimal return policy assists in aggregating the double marginalization and improving the channel's efficiency. Third, I investigate the model where the quota policy replaces the partial refund policy: the retailer receives the full refund for the returned items if the returned quantity is within the quota otherwise no refund for the retailer. I find that there exists an equivalent relationship between the partial refund policy and the quota policy: in equilibrium the quota is exactly the ratio of the refund to the wholesale price. Fourth, I study the model where the retailer can choose either send back the returned items to the manufacturer with refund or resell them to the outside market with a salvage price. In equilibrium the retailer always chooses to resell the returned items directly to the outside market. Moreover, the manufacturer's profit is lower than the case that the manufacturer resells the returned items but the whole's channel's profit is higher and even exactly the same as the integrated channel's profit, which indicates that there exists no double marginalization.

In the second essay, “**Pricing with Valuation Uncertainty using Dynamic Mechanism Design**”, I model the scenario where consumers pay (get paid or receive free) to try the product in the 1st period and realize their valuations about the product before their final purchase in the 2nd period. Consumers pick up the price path and decide their final purchase at the two different time periods. Therefore, I

propose and solve a sequential screening model based on the framework of dynamical mechanism design. It is interesting to note that there is an equivalent connection between this model and the integrated channel model discussed in the 1st essay: in equilibrium, the trial fee equals to the difference between the full price and refund and the price for the final purchase equals to the refund. We use the same assumption (mean preserving spread) on the consumer market segmentation and examine the impact of learning cost induced during the product trial period. I find that if the learning cost difference between two segments and the fraction of the H consumer segment are small enough then there exists the discrimination on price paths. There is an interwoven price pattern for these price paths: for the H segment the trial fee is lower and the final purchase price is higher than the L segment. I also find that if the condition for the discrimination holds and the learning costs are large enough then the seller subsidizes the H consumer segment to try the products. This result explains the freemium marketing phenomena without leveraging any externality effects. I also investigate the impact of the valuation variance change and find that when the valuation uncertainty is reduced by the same amount for both segments the seller's profit will increase if the learning cost difference is small enough. This result is contradictory to the common understanding about the valuation uncertainty: the more consumer's uncertainty the higher seller's profit. Furthermore, I analyze the introduction of an upgraded product after the trial period if the learning costs are the same for both segments. If the upgraded level cannot be controlled by the seller, I find that: when the invention cost and upgraded level are small, then it is cheap for the seller to design and invent the upgraded product and hence the seller is better off by introducing the upgraded product to consumers. If the upgraded level can be fully controlled by the seller, then the seller can carefully design the upgraded level and prices such that it is always optimal to offer the upgraded product.

**“The Effect of Switching Cost on The Competition Between Local and Online Firms”, with Amit Pazgal, submitted to Journal of Retailing.**

In this paper we study the competition between local and online firms in a two-period model where switching costs are present in the second time period. In contrast to the standard switching cost literature, both the “lock in and ripoff” and the “lock in and no ripoff” patterns are found to exist in equilibrium. All firms prefer to lower their first-period prices in order to attract more consumers. However, in the second period, when the disutility of using the online provider is high, the local retailers prefer to charge their previous customers a higher price. The online provider tends to charge a lower price to maintain its previous customers and maybe attract new ones, which forms the “ripoff” pattern for the local retailers and “no ripoff” pattern for the online provider. Conversely, when the online disutility is low, “no ripoff” pattern is established for the local retailers and the “ripoff” pattern is developed for the online provider. Furthermore, we also find that when the firm is better off with switching costs it prefers to increase the switching costs further resulting in even higher profits. Not only do we find the monotonic relationships between the revenue and switching costs but we also observe the more general U-shape relationship. We offer two extensions of our model: one considers the effect of loyal consumers and the other studies the competition between  $n \geq 2$  local retailers and an online provider.

**“Pricing with Valuation Uncertainty using Dynamic Mechanism Design”, with K. Sudhir and Amit Pazgal, will be submitted to Management Science.**

The paper studies price discrimination in price paths over first and subsequent purchase in settings where consumers have *uncertainty over their valuation distributions* for the product at the time of first purchase and realize their valuation after first purchase by incurring a *learning cost* that is different from price. Consumers pay (get paid or receive free) the product to try in the first period, incur an additional learning cost to realize their valuation before deciding to purchase the product in the second period. We propose and solve a sequential screening model based on dynamic mechanism design where forward looking consumers are offered an optimal menu of price paths over the two periods that price discriminates over the valuation uncertainty and learning costs. Price discrimination is feasible when learning costs are higher for the high valuation uncertainty segment. The firm offers a relatively lower first period price (including free or subsidies) for the higher learning cost-higher uncertainty segment, but a higher second period price; overall their total cost across both periods are higher. More consumers are excluded from second period purchase among the higher valuation uncertainty segment—as the firm seeks to obtain greater profits from those with the highest valuations from the higher uncertainty segment. Our model offers a dynamic screening explanation for the use of freemiums, even in settings without cross-customer externalities. We find that online reviews that reduce the variance in prior valuation distributions can dampen seller profits and the ability to offer upgrades in the second period can enhance the ability to price discriminate on valuation uncertainty more effectively and increase seller profits.

**“Heterogeneous Value Uncertainty in Online Channels: Dynamic Mechanism Design of Price and Return Policies”, with K. Sudhir, Amit Pazgal, submitted to Management Science.**

Consumers differ in their match uncertainty when buying through online retail channels. Generous return policies can encourage purchasing in the presence of significant ex-ante match uncertainty, but need higher prices to support them. Given heterogeneity in match uncertainty among consumers, retailers can jointly discriminate over a menu of upfront retail price and post-purchase refund costs. As consumer uncertainty over matching is resolved over time only after purchase, discrimination using a menu over retail price and refund costs is a sequential screening problem that requires a dynamic mechanism design based analysis. Further, since returns are costly to retailers, manufacturers can find it optimal to share risk with the retailer by optimizing over their wholesale prices and refunds to retailers on items returned. We model the channel in a leader-follower framework with the manufacturer as the leader choosing wholesale pricing and refund terms and retailer as the follower solving a sequential screening problem to price discriminate on uncertainty. To the best of our knowledge, we are the first to introduce the sequential screening problem in a dynamic mechanism design framework into marketing. We find that the retailer finds it optimal to price discriminate on price paths only if manufacturers offer refunds on returned products or there is some salvage value for the product.

**“Price Adjustment Policy with Partial Refunds in Channel”, with Amit Pazgal, Dinah Cohen-Vernik, manuscript in progress.**

In this paper we study the price adjustment policy by which the consumers can ask for the refund from the seller for the purchased product whose current price is lower than before. We investigate the impact of the price adjustment policy on the channel where the refund can be either paid by the manufacturer or the retailer and analyze under which condition such policy actually brings more profit to the sellers. In practice, either the full refund or no refund is applied. In contrast, our results demonstrate that if both the sellers and consumers think that the product’s value decays slowly in time then the partial refund will be a better choice. Furthermore, we also carefully study under which condition the manufacturer (retailer) should pay the refund to the consumers in order to gain more profit.