ASU W. P. CAREY SCHOOL of BUSINESS
ARIZONA STATE UNIVERSITY

Morrison School of Agribusiness

7231 E. Sonoran
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Mesa, AZ 85212

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September 9, 2019

The Department of Agricultural Economics
College of Agriculture and Life Sciences,
Texas A&M University
2124 TAMU, College Station,
Texas 77843-2124

Dear Dr. Waller,

I am writing to apply for the position of Assistant Professor in the Department of Agricultural Economics at Texas A & M University. I am currently a Ph.D. candidate in the Morrison School of Agribusiness at W. P Carey School of Business, Arizona State University. I will defend my dissertation in April 2020. My research focuses on identifying mechanisms that lead to efficient production and marketing of perishables in the food supply chain.

In my dissertation, "Managing food loss and waste in the supply chain", I investigate the impact of contract farming on food loss in India and online and offline grocery shopping on household food waste in the United States. For the study on food loss, I surveyed 600 okra growers in two districts of Karnataka, a state in India, in 2018. I use both analytical (with simulations) and empirical (regression discontinuity design (RDD)) approaches in this study. Using the RDD approach, I find that contractors or agribusiness firms rejected a significant quantity of the produce as it failed to meet quality standards. To analyze the impact of the rejected quantity of produce on food loss, I use an analytical approach followed by simulations with different labor and transport costs. I found that lowering labor and transport costs for the smallholder growers would reduce food losses. For the study on household food waste, I use scanner data of a popular retailing chain in the United States. I focus on the behavior of impulse buying and the size of purchases of a household with respect to bakery purchases. I expect these behaviors to play a significant role.

The dissertation provides evidence on how grower's production and household's shopping decisions impact food loss and waste. These studies identify policies related to the decision-making process of growers and grocery shoppers respectively. Growers' decision on reducing the rejected quantity and selling produce to the spot markets impact the magnitude of food loss. On another hand, grocery shopper's choice of shopping channel and decisions on how much to purchase plays a significant role in impacting the magnitude of food waste.

The study on food loss using the regression discontinuity approach is currently under review in *Food Policy.* While I plan to submit the analytical approach of the food loss paper to *Production and Operations Management*. The study on food waste will be submitted to *American Journal of Agricultural Economics*. I have presented my study at the Applied and Agricultural Economics Association (AAEA), 2019 in Atlanta and the Institute for Operations Research and the Management Sciences (INFORMS), 2018 in Phoenix and 2019 in Seattle.

Previously, I have studied efficient means of production and marketing in the food supply chain. I examined the impact of conservation technologies on smallholder growers' yield, costs, and profits (Food Security, 2015; 2018 & Land Use Policy, 2018). I have also studied the impact of contract

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farming on profits of smallholder growers (The Australian Journal of Agricultural Economics, 2018; Food Policy, 2016), on production risks and food security of the smallholder growers (Applied Economic Perspectives and Policy, 2018) and on whether contractors in the form of co-operatives benefit smallholder growers (Agribusiness, 2018). Apart from contract farming, I also studied the impact of the non-farm activities of rural households on diet quality. This study has been accepted for publication in the forthcoming issue of *Agricultural Economics.*

My teaching objective is to provide practical knowledge and real-life examples to students so that they think critically about course concepts. I do this by complementing lectures with experimental games, videos, and field trips. I also encourage student involvement through small group discussions and debates to necessitate active participation. In "Global Food and Agricultural Policy," students work on topics of trade disputes between countries of their choice. I mentored each student in learning how to use publicly available data to motivate their projects. They were then asked to present and ask each other questions. The grading was done based on their involvement. By this approach, they learned from each other about different topics from different countries. In the course on "Problem Solving and Actionable Analytics," I provided hands-on training of various statistical programs (Excel, Excel Miner, STATA & SQL) to demonstrate different ways of analyzing data. Students work on group projects of their choice applying research methods taught in the class. After choosing the research problem of their choice, I guided them in choosing the appropriate research method, data, and structure of analysis. Students chose research topics ranging from the impact of self-driving cars in studying the effects of online music on the music industry. I also taught an online course on "Business Operations and Planning," which equipped students with the terms and concepts of supply chain management and its application in our daily lives. At Texas A&M, I am prepared to teach both core courses (Agribusiness Management, Agricultural Marketing, International Trade, Agricultural Economics, Econometrics, and Economic Development) and topic-centered courses. I am also willing to mentor undergraduate and graduate students.

The Texas A&M AgriLife Research's mission of benefitting consumers and creating a sustainable, profitable and environment friendly agricultural sector is appealing to me. My research on food waste, food safety, and food security is consistent with the mission of making the U.S. agricultural sector successful benefitting all the stakeholders. Furthermore, I am particularly interested in this position because it requires conducting collaborative research with a particular focus on policymaking in the field of food and agricultural systems. I envision working on the topics of supplier-buyer (grower & contractor) relationships, labor shortages, logistics, and food safety in the U.S. food supply chain.

I look forward to hearing from you soon. Thank you.

Sincerely,

Alwin D'souza

Alwin Dsouza

# Alwin D'souza

Address: 1500 E Broadway Rd, Apt. 2137 E, Tempe, AZ- 85282
Phone: (480)-420-4215 | Email ID: adsouza3@asu.edu | Skype ID: alwdsouza@gmail.com

## Education

- **Morrison School of Agribusiness, Arizona State University** — **Arizona, United States**
  Ph.D. Business Administration (Agribusiness) with a concentration in Supply Chain — Expected April 2020
  *Research Interests:* Production Economics, Contract Farming, Food Waste, Food Access, Food Security and Health Economics.
  *Dissertation title:* Managing Food Waste and Food Loss in the Supply Chain
  *Dissertation committee:* Ashok Mishra, Ph.D. (Chair), Timothy Richards, Ph.D., Scott Webster, Ph.D.
- **Centre for Int. Trade and Development, Jawaharlal Nehru University** — **New Delhi, India**
  M.Phil. Economics — 2011-2013
- **Gokhale Institute of Politics and Economics** — **Pune, India**
  M.A. Economics — 2008-2010
- **Calcutta University** — **Kolkata, India**
  B.Sc. Economics — 2004-2007

## Teaching Experience

- **Morrison School of Agribusiness, Arizona State University** — **Arizona, United States**
  Instructor (Online), BUS 384 "Business Operations and Planning" — May 2019–June 2019
  Teaching Assistant, BUS 384 "Business Operations and Planning" — January 2019-May 2019
  Teaching Assistant, AGB 302 "International Management and Agribusiness" — August 2018 – December 1018
  Co-Instructor, WPC 300 "Problem Solving and Actionable Analytics" — January 2018–May 2018
  Instructor, AGB 452 "Global Food and Agricultural Policy" — August 2017–December 2017
- **Centre For Int. Trade and Development, Jawaharlal Nehru University** — **New Delhi, India**
  Instructor, Graduate level "Intermediate Economics — January 2012–May 2012

## Research Experience

- **Morrison School of Agribusiness, Arizona State University Arizona, US**
  *Graduate Research Associate* — *May 2018–August 2018*
  - Project title: " ***Food Loss and Waste for Produce: Economic Abandonment*** " funded by USDA ERS.
  - Designed a flow chart on food loss in tomato and potato supply chain
  - Formulated the linear programming for food loss in potato, processed tomatoes, romaine lettuce, and peaches focusing on storage, labor costs for picking and sorting respectively.
- **Morrison School of Agribusiness, Arizona State University Arizona, US**
  *Graduate Research Associate* — *August 2015–August 2017*
  - Project title: "***Contract farming in Nepal and India***"
  - Reviewed literature, performed econometric analysis, and worked on the manuscript for peer-reviewed journals.
  - Papers from this project have been published in Food Policy, Australian Journal of Agricultural and Resource Economics and Applied Economic Perspectives and Policy.
- **International Maize and Wheat Improvement Centre (CIMMYT) New Delhi, India**
  *Research Associate* — *November 2013–July 2015*
  - Project title: "***Cereal Systems Initiative for South Asia (CSISA)***" funded by Bill and Melinda Gates Foundation (BMGF).
  - Responsible for designing questionnaires, training enumerators, conducting and leading group discussions with farmers in one of the remote and underdeveloped states in India.
  - Involved in the analysis of data and writing for peer-reviewed publications. Three papers from this project have been published in Food Security.

- **Integrated Research and Action for Development (IRADe) New Delhi, India**
  *Research Assistant* *June 2010–August 2011*
  - Project title: "***Transforming Indian Agriculture-India, 2040***" funded by Centennial Group International.
  - Worked on CGE modeling and Activity Analysis, especially for the agricultural sector of the Indian Economy.
  - Engaged in aggregating the social accounting matrix from 140 sectors to important 10 sectors of the economy and estimating the demand systems for India, especially for the agricultural commodities.
  - Three papers from this project have been published in peer-reviewed journals. The report was published under the title "Transforming Indian Agriculture-India 2040: Productivity, Markets, and Institutions".

- **International Food Policy Research Institute (IFPRI) New Delhi, India**
  *Internship* *June 2009–August 2009*
  - Performed quantitative and qualitative research on the rise of the corporate sector in the retail market.
  - Conducted analysis based on primary data collected through field visits and secondary data.
  - Organized and prepared a case study on "Role of corporate and co-operatives in the horticulture sector in Maharashtra."

## Peer Reviewed Publications

- **Dsouza, Alwin**.; Mishra, Ashok., and Hirsch, S. 2019 "Enhancing food security through diet quality: the role of non-farm work in rural India", Agricultural Economics *forthcoming.*

- Mishra, Ashok.; Kumar, Anjani.; Joshi, P.K., and **Alwin, D'souza**. 2018 "Production Risks, Risk Preference, and Contract Farming: Impact on Food Security in India," *Applied Economic Perspectives and Policy*, Vol. 40 (3), 353-378.

- Mishra, Ashok.; Kumar, Anjani.; Joshi, P.K., and **Alwin**, **D'souza.** 2018 "Impact of Contract Farming on Yield, Costs, and Profitability in Low-Value Crop: Evidence from a Low-Income Country," *The Australian Journal of Agricultural and* Resource Economics, Vol. 62 (4), 589-607.

- Mishra, Ashok.; Kumar, Anjani.; Joshi, P.K., and **Alwin**, **D'souza.** 2018 "Cooperatives, Contract Farming, and Farm Size: The Case of Tomato Producers in Nepal," *Agribusiness an international journal*, Vol. 34(4), 865-886.

- Mishra, Ashok.; Kumar, Anjani.; Joshi, P.K., **D'souza, Alwin**; and Gaurav Tripathi. 2018 "How can Organic Rice be a Boon to Smallholders? Evidence from Contract Farming in India", *Food Policy*, Vol. 75, 147-157.

- **D'souza, Alwin,** and Amit S Ray. 2018 "Structural Transformation in North Eastern Region of India- Charting Out an Agricultural Based Policy," *Agrarian South: Journal of Political Economy*, Vol. 6(3), 373-394.

- **D'souza, Alwin,** and Ashok Mishra. 2018 "Adoption and Abandonment of Partial Conservation Technologies in Developing Economies: The Case of South Asia," *Land Use Policy*, Vol. 70, 212-223.

- Mishra, Ashok.; Kumar, Anjani.; Joshi, P.K and **Alwin D'souza.** 2016 "Impacts of Contracts in High Yielding Varieties Seed Production on Profits and Yield: The Case of Nepal," *Food Policy*, Vol.62, 110-121.

- Parikh, Kirit.; Ghosh, Probal.; **D'souza, Alwin** and Hans P. Binswanger-Mkhize. 2016 "Estimating Consumer Demand System for Agricultural Goods in India," *Indian Journal of Agricultural Economics*, 71 (2), 113-136.

- Keil, Alwin.; **D'Souza, Alwin** and Andrew J McDonald. 2016 "Growing the Service Economy for Sustainable Wheat Intensification in the Eastern Indo-Gangetic Plains: Lessons from Custom Hiring Services for Zero Tillage" *Food Security*, Vol 8 (5), 1011-1028.

- **Dsouza, Alwin.**; Singh, Sudershan and Rahul Ranjan. 2016 "Does Socio-Religious Identity Lead to Structural Disadvantage? Evidence from The Indian Labour Market", *Indian Journal of Labour Economics*, Vol 58, 545-561.

- Keil, Alwin.; **D'Souza, Alwin** and Andrew J McDonald. 2015 "Zero-Tillage Wheat as a Pathway for Sustainable Intensification in The Eastern Indo-Gangetic Plains: Does it Work in Farmers' Fields?", *Food Security* Vol 7 (5), 983-1001.

- Bathla, Seema., and **Alwin D'souza**. 2015 "Inter-Sectoral Productivity Differential in India: Is Convergence Achievable?", *South Asia Economic Journal*, Sage Publications, Vol 16(1).

- Bathla, Seema.; Bhattacharya, Paramita and **Alwin D'souza**. 2015 "India's National Food Security Act 2013: Food Distribution System or Food Stamps and Cash Transfers?", *Agricultural Economic Research Review*, AERA (India), Vol 28 (1).

- Binswanger-Mkhize, Hans P., and **Alwin D'Souza**. 2012 "Structural Transformation and Agricultural Productivity in India." in *Productivity Growth in Agriculture: An International Perspective*, edited by Keith Fuglie, Sun Ling Wang and Eldon Ball of the USDA, CABI, Oxfordshire, U.K.

- Binswanger-Mkhize, Hans P., and **Alwin D'Souza**. 2012 "India, 1980-2008, Structural Change at the State Level.", *Agricultural Economic Research Review*, AERA (India), Vol.28 (1).

## Papers Presented in Conferences

- **D'souza, Alwin.**; Webster, Scott, and Ashok Mishra. "Assessing Post-harvest Losses Under Vertical Coordination – Evidence from An Emerging Economy" will be presented at INFORMS, Seattle, 2019

- **D'souza, Alwin.**; Mishra, Ashok, and Scott Webster. "Designing Vertical Linkages to Reduce Food Loss" paper presented at Agricultural and Applied Economics Association, Atlanta, 2019.

- **D'souza, Alwin.**; Chenarides, Lauren and Timothy Richards. "Food Waste in Online Vs. Offline Grocery Shopping" paper presented at INFORMS, Phoenix, 2018.

- **D'souza, Alwin**, and Ashok. K. Mishra. "Improving Diet Quality through Off-Farm Work: Empirical Evidence from India" paper presented at Agricultural and Applied Economics Association, Washington D.C., 2018.

- **D'souza, Alwin,** and Hans P Binswanger. "Structural Transformation of Indian Economy: 1961 to 2010" paper presented at ReSAKSS as an invited speaker, organized by IFPRI, TDRI, and USAID at Bangkok, 2017.

- **D'souza, Alwin,** and Ashok K. Mishra. "Enhancing Food Security through Diet Quality: The Role of Casual Off-Farm Work in Rural" paper presented at Arizona Wellbeing Commons, Tempe, 2017.

- **D'souza, Alwin**, and Ashok K. Mishra. "Adoption and Abandonment of Conservation technologies: a case of South Asia," paper presented at Agricultural and Applied Economics Association, Boston, 2016.

- Keil, Alwin.; **D'Souza, Alwin** and Andrew J McDonald. "Zero-tillage for Sustainable Productivity Increases in Wheat in the Indo-Gangetic Plains: Does it Work in Farmers' Fields?" presentation in the International Conference of Agricultural Economists (ICAE) in Milan, Italy, 2015.

- **Dsouza, Alwin,** and Amit S Ray. "Structural Transformation in North Eastern region of India- Charting out an Agricultural based policy," paper presented in IFPRI-IEG International Conference, Dec 2014, New Delhi.

- **Dsouza, Alwin.**; Singh, Sudershan and Rahul Ranjan. "Does Discrimination Play a Role in Wages," paper presented in The Indian Econometric Society, India, Dec 2014.

## Leadership Positions/Service

- Assembly member, W P Carey School of Business, Graduate and Professional Student Association (GPSA) (2017-2018; 2018-2019)
- Treasurer, Morrison School of Agribusiness Graduate Student Organization (2018-19; 2019-present)
- Member of the Internal Affairs Committee, GPSA (2017-2018, 2018-2019)
- Member of the Diversity and Inclusion Affairs Committee, University Board, ASU (2018-2019)

- Member of the Professional Development, GPSA (2017-2018)
- President of the Anglican Campus Fellowship, Arizona State University since 2015.
- Judge at the Future Farmers of America (2015, 2016 and 2017)
- Academic Knowledge Expert at the Policy Talks (https://www.policytalks.in/team)
- **Journal Referee***
  - African Journal of Agricultural Research (Academic Journals),
  - Agribusiness (Wiley),
  - Applied Economics (Taylor and Francis),
  - European Journal of Development Research (Palgrave MacMillan, Springer),
  - Food Security (Springer),
  - Food Policy (Elsevier),
  - Journal of Agribusiness in Developing and Emerging Economies (Emerald Publishing),
  - Journal of Co-operative Organization and Management (Elsevier),
  - Journal of Crop Improvement (Taylor and Francis),
  - Land Use Policy (Elsevier),
  - The Australian Journal of Agricultural and Resource Economics (Wiley).
    * Refer to publons for more information (https://publons.com/researcher/1570882/alwin-dsouza/peer-review/)

## Honors/Awards/Achievements

- Outstanding Reviewer, Journal of Agribusiness in Developing and Emerging Economies, 2019.
- Achieved 140 google citations and H-Index of 6 (https://scholar.google.com/citations?user=VgchAzsAAAAJ&hl=en)
- Second prize, ICSSR poster competition, Arizona State University, Spring 2019,
- Awarded for the most distinguished student organization (Anglican Campus Fellowship), ASU 2017-2018 (out of 728 organizations).
- Honorary Mention for the ICSSR poster competition, Spring 2016, Arizona State University.
- Recipient of Dr. D.K. Desai award for the best article published in the Indian Journal of Agricultural Economics for the year 2016.
- Recipient of Dr. R.T. Doshi award for the best article published in Agricultural Economics Research Review for the year 2015.
- Dsouza and Mishra (2018) cited by Nature Sustainability (https://www.nature.com/articles/s41893-017-0018-4)

## Grants

- The Travel Grant for Early Career Professionals and Graduate Students, AAEA, 2018 ($500), 2019 ($465)
- Graduate and Professional Student Association Travel Grant (2019) ($960)
- Richard Gordan Scholarship, 2018 ($500)
- The James Sweitzer Memorial Scholarship, 2015-2016 ($2000) , 2016-2017 ($800)

## Analytical and Technical Skills

- **Quantitative:** Survey Design| Statistical modeling | Linear Programming | Agent-based modeling | Machine Learning
- **Qualitative:** Interviews | Focus group discussions
- **Language:** Python
- **Statistical Software:** STATA | SPSS | SAS | GAMS| @Risk | ArcGIS | QGIS | R | Nlogit | NetLogo | LaTeX

## References

Ashok K. Mishra, Ph.D.
Kempler and Ethel Marley Foundation Chair
Morrison School of Agribusiness
W. P Carey School of Business
Arizona State University
7231 E Sonoran Arroyo Mall
Mesa, AZ 85212
Email: Ashok.K.Mishra@asu.edu

Timothy Richards, Ph.D.
Morrison Chair of Agribusiness
Morrison School of Agribusiness
W. P. Carey School of Business
Arizona State University
7231 E. Sonoran Arroyo Mall
Mesa, AZ 85212
Email: trichards@asu.edu

Scott Webster, Ph.D.
Bob Herberger Arizona Heritage Chair
W. P. Carey Supply Chain Management
Arizona State University
BA 424
Tempe, AZ 85281
Email: Scott.Webster@asu.edu

# Arizona State University

## Unofficial Transcript

**Name:** **Alwin Dsouza**
**Student ID:** **1209966872**

Print Date: 08/15/2019
External Degrees
Jawaharlal Nehru University
Master of Philosophy 03/01/2014

University of Calcutta
Bachelor of Economics 05/01/2007

**Beginning of Graduate Record**

**2015 Fall**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 701** | **Advanced Agribusiness I** | 3.000 | 3.000 | A | 12.000 |
| **ECN 525** | **Applied Regression Models** | 3.000 | 3.000 | B+ | 9.999 |
| **ECN 594** | **Conference and Workshop** | 2.000 | 0.000 | X | 0.000 |
| Course Topic: | Math Economics | | | | |
| **MGT 791** | **Seminar** | 1.000 | 1.000 | A | 4.000 |
| Course Topic: | Research Ethics | | | | |
| **SOS 512** | **Sustainable Resource Allocaton** | 3.000 | 3.000 | B+ | 9.999 |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 3.60 | Term Totals | 10.000 | 10.000 | 35.998 |
| Cum GPA: | 3.60 | Cum Totals | 10.000 | 10.000 | 35.998 |

**2016 Spring**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 702** | **Advanced Agribusiness II** | 3.000 | 3.000 | A | 12.000 |
| **ECN 510** | **Microeconomic Theory/Applicatn** | 3.000 | 3.000 | B | 9.000 |
| **GIS 598** | **Special Topics** | 3.000 | 3.000 | A+ | 12.999 |
| Course Topic: | Geographic Info Analysis | | | | |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 3.78 | Term Totals | 9.000 | 9.000 | 33.999 |
| Cum GPA: | 3.68 | Cum Totals | 19.000 | 19.000 | 69.997 |

**2016 Fall**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 703** | **ADV AGB III: ADV Empirical Mo** | 3.000 | 3.000 | B | 9.000 |
| **FIN 781** | **Theory of Finance** | 3.000 | 3.000 | B+ | 9.999 |
| **FIN 783** | **Empirical Asset Pricing** | 3.000 | 3.000 | A- | 11.001 |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 3.33 | Term Totals | 9.000 | 9.000 | 30.000 |
| Cum GPA: | 3.57 | Cum Totals | 28.000 | 28.000 | 99.997 |

**2017 Spring**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **PSY 576** | **Dynamical Systems in Psych** | 3.000 | 3.000 | A- | 11.001 |
| **PSY 591** | **Seminar** | 1.000 | 1.000 | B | 3.000 |
| Course Topic: | Dynamics in Psychology | | | | |
| **SCM 791** | **Seminar** | 3.000 | 3.000 | B+ | 9.999 |
| Course Topic: | Analytical Research Methods | | | | |
| **SCM 791** | **Seminar** | 3.000 | 3.000 | A | 12.000 |
| Course Topic: | Logistics | | | | |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 3.60 | Term Totals | 10.000 | 10.000 | 36.000 |
| Cum GPA: | 3.58 | Cum Totals | 38.000 | 38.000 | 135.997 |

**2017 Fall**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 791** | **Seminar** | 3.000 | 3.000 | A | 12.000 |
| **AGB 792** | **Research** | 6.000 | 6.000 | A | 24.000 |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 4.00 | Term Totals | 9.000 | 9.000 | 36.000 |
| Cum GPA: | 3.66 | Cum Totals | 47.000 | 47.000 | 171.997 |

**2018 Spring**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 792** | **Research** | 6.000 | 6.000 | A | 24.000 |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 4.00 | Term Totals | 6.000 | 6.000 | 24.000 |
| Cum GPA: | 3.70 | Cum Totals | 53.000 | 53.000 | 195.997 |

**2018 Fall**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 799** | **Dissertation** | 6.000 | 6.000 | Y | 0.000 |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 0.00 | Term Totals | 6.000 | 6.000 | 0.000 |
| Cum GPA: | 3.70 | Cum Totals | 59.000 | 59.000 | 195.997 |

**2019 Spring**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 799** | **Dissertation** | 6.000 | 6.000 | Y | 0.000 |

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 0.00 | Term Totals | 6.000 | 6.000 | 0.000 |
| Cum GPA: | 3.70 | Cum Totals | 65.000 | 65.000 | 195.997 |

**2019 Fall**

| Course | Description | Attempted | Earned | Grade | Points |
|---|---|---|---|---|---|
| **AGB 799** | **Dissertation** | 1.000 | 0.000 | NR | 0.000 |
| **BMI 555** | **Stat Learning for Data Mining** | 3.000 | 0.000 | NR | 0.000 |
| **GRD 791** | **Seminar** | 2.000 | 0.000 | NR | 0.000 |
| Course Topic: | Prep Future Fac & Schol (PFx) | | | | |

# Arizona State University
**Unofficial Transcript**

**Name:** **Alwin Dsouza**
**Student ID:** **1209966872**

| | | | Attempted | Earned | Points |
|---|---|---|---|---|---|
| Term GPA: | 0.00 | Term Totals | 0.000 | 0.000 | 0.000 |
| Cum GPA: | 3.70 | Cum Totals | 65.000 | 65.000 | 195.997 |

END OF TRANSCRIPT

September 12, 2019

Dr. Mark L. Waller,
Professor and Acting Department Head,
Department of Agricultural Economics,
2124 TAMU, College Station,
Texas 77843-2124.

Dear Dr. Waller,

It is with great pleasure that I write a letter in support of Mr. Alwin Dsouza for an Assistant Professor's position for Agricultural Marketing and Quantitative Analysis in your Department. I believe that Alwin is the best candidate for the job. Also, along with a **Ph.D. in Agribusiness,** Alwin has taken doctoral-level courses in Supply Chain. The combination of a Ph.D. with a concentration in Supply Chain will prove to be very beneficial to your agribusiness program and the department.

Alwin is one of our best Ph.D. students in many years. Alwin is an independent thinker, possesses problem-solving skills, and works well with other researchers and economists. Alwin has programming (R, STATA, and SAS) and communication skills, understanding of theory and writing skills. For the last four years, he has worked with me where his research focused in the field of applied economics. He has authored/co-authored *17 papers in refereed journals* and *one article in review* which I believe will result in publications soon. He has also made *seven presentations in professional conferences* while maintaining a cumulative GPA of 3.7. The publications are in ISI journals (*Agricultural Economics, Food Policy; The Australian Journal of Agricultural and Resource Economics, Agricultural Economics: An International Journal; Land Use Policy Journal; Applied Economic Perspectives and Policy, to* name a few). These facts demonstrate that he is a hard worker with a dedication to the issues related to agribusiness and supply chain.

In the classroom setting, he served as an instructor of the record for *Global Food and Agricultural Policy*—senior level— and co-instructed *Problem Solving and Actionable Analytics* at ASU. Alwin also taught *Business Operations and Planning* as an online instructor. He served as a graduate teaching assistant in International Management and Agribusiness. I have heard from the Professors that he did an excellent job in the classroom setting. Alwin also represented WP Carey School in the Student Graduate Association of ASU. Alwin always demonstrates enthusiasm for learning new knowledge and mastering novel techniques. He is continuously curious about new estimation procedures and their application to solving real-world problems. He is currently taking a course in Machine Learning hoping to apply it to his research.

Alwin has knowledge of production economics, farming, food supply chain and agricultural marketing. For his research, he visited farmers and contracting companies in India. Alwin gathered primary data for his Ph.D. dissertation. He has also developed several ideas related to contract farming, food security, and diet quality for research during his graduate studies here at ASU. Several working papers and a couple of publications have resulted from this endeavor. He has been invited to present his research at The Institute for Operations Research and the Management Sciences (INFORMS) in 2018 and 2019. He was a plenary speaker at an international conference in Bangkok in 2017, organized by the International Food Policy Research Institute and the United States Agency for International Development.  He has reviewed papers for top ranking peer-reviewed journals and has been awarded the Ouststanding Reviewer Prize for 2019 by the *Journal of Agribusiness in Developing and Emerging Economies*.

Alwin has received several awards along the way—a recognition for his quality work. His preparation, delivery, and presentation of his research are well delivered. He was also acknowledged by Dr. Micheal Crow, President of ASU, for the poster competition at ASU and focusing his research on public issues of food waste, contracting and issues of sustainability. Throughout the process, Alwin has shown that he can work independently and use his knowledge to undertake a project and see it toward completion. Alwin has produced more than any other student in the department and has the potential to be productive in the future.

Therefore, from the remarks above, I have no hesitation in recommending Mr. Alwin Dsouza for an Assistant Professor's position in the Department of Agricultural Economics at The Texas A&M University. I hope you give him careful consideration as you make your final decision. Please do not hesitate to call me at 480-727-1288 or email me at Ashok.K.Mishra@asu.edu if you need additional information.

Sincerely,

AKMishra

Ashok K. Mishra
Kemper and Ethel Marley Foundation Chair
Morrison School of Agribusiness | W.P. Carey School of Business
Arizona State University | Mesa, AZ 85212

Editor, *Agricultural Economics: An International Journal*
Editor, *Journal of Agribusiness in Developing and Emerging Economies*
Series Editor, *Routledge Series in Agricultural Economics*

**W. P. Carey School of Business**
**Arizona State University**

7231 E. Sonoran Arroyo Mall Mesa, AZ 85212

10 September 2019

Subject: Letter of Reference

To search committee:

In this letter, I provide a recommendation for the position you advertised for Alwin Dsouza, who is currently a Ph.D. (Business Administration) student in the Morrison School of Agribusiness, W. P. Carey School of Business at Arizona State University. To summarize my letter at the outset, I regard Alwin as one of the most capable and accomplished Ph.D. students I have encountered, and is likely to make a lasting contribution to not only research in agribusiness defined generally, but to make a substantial intellectual contribution to how food is marketed and sold in the U.S., and in international settings.

I am on Alwin's doctoral committee, and am the Marvin and June Morrison Chair in Agribusiness. I am also the Ph.D. program coordinator, and teach one of the three core Agribusiness Ph.D. classes, so have been closely involved with his progress for a number of years. I have spent some time working with Alwin on his dissertation, and on the paper for my class, so I feel well-qualified to comment on his aptitude as a scholar. I write this letter to provide some specific comments on his dissertation research, a general perspective on his research skills, his teaching ability, and his likely contribution to your faculty.

I would describe Alwin's field of study as quantitative marketing applied to food systems, as his dissertation concerns alternative sources of food waste in the distribution channel. Understanding food waste requires knowledge of not only marketing systems, from the retail to the consumer end, but also of production systems and supply chains more generally. We have two AFRI-NIFA grants on food waste, so Alwin has been able to weave his research into our funded research stream. I expect each of the papers from his dissertation will be well-published.

I can speak most directly of the quality of his work on the essay he is doing with me. For these essays, the central motivating question is approximately the same: Why do agents at different levels of the food supply chain waste food, and what are the appropriate policy responses?

In his third essay, Alwin is exploring the potential for online food purchases to reduce the amount of food wasted at the household level. Fully 2/3 of the food wasted in the US, some \$165.0 billion per year (Buzby and Hyman 2012), derives from the household level, so we cannot properly understand solutions to the broader problem unless we first get a handle on how household purchase, and use, the food they buy. There is a large literature on how online food purchasing differs from offline purchasing: While online baskets are larger, suggesting greater scope for waste, consumers are also more likely to use lists, plan ahead, and resist impulse buying online, each of which are likely to reduce food waste. Alwin is using the Bluesky data from the Giannini Founding at U. C. Berkeley to investigate this question empirically. The Bluesky data is one of the best sources for online and offline data, so Alwin has the opportunity to test a number of hypotheses regarding how much food consumers waste when they purchase online relative to offline. His research, which will likely be published in a top agricultural economics journal, informs not only the policy literature on food waste, but also the empirical marketing literature on online versus offline purchasing. In this regard, I expect his research to have a major impact on the field.

Alwin has presented his research a number of times, both at the Agricultural and Applied Economics Association (AAEA) and the INFORMS meetings. Alwin is comfortable in front of any audience, and communicates his research very well. He is incredibly resourceful and creative, and remains my go-to person for creating engaging graphics for my own presentations. Perhaps most importantly, he is very personable, and will, without a doubt, immediately assemble effective research teams around himself as soon as he graduates. Beyond these soft-skills, he is a good econometrician, and feels very much at home designing increasingly-complicated experiments. Overall, I would place him in the top 10% of all Ph.D. students I have either mentored or collaborated with in my career.

Please let me know if you have any questions regarding this letter, and don't hesitate to contact me by email at trichards@asu.edu or by phone at 480-727-1488.

Best regards,

Dr. Timothy J. Richards
Morrison Chair of Agribusiness

cc: Timothy J. Richards

W. P. Carey School of Business
Arizona State University

September 12, 2019

Dear reader:

I am writing this letter of reference for Alwin Dsouza who is applying for a faculty position at your school. I know Alwin well.

Alwin was a student in my PhD seminar, *Analytical Research Methods*, in spring semester 2017. During the seminar, Alwin presented three research papers that relate to food supply,[1] covering what the paper is about, its main findings, and working through proofs/derivations. He submitted weekly problem sets and took a final exam. He performed well, receiving a final grade of $B^+$.

I am advising Alwin on a thesis essay that focuses on two main goals. First, he seeks to understand how characteristics of the environment (crop, market, growing/production system, farmer contract form) interact to affect food loss and farmer welfare. From this understanding, he seeks to provide guidance to a policy-maker interested in actions to reduce food loss and improve (or at least not harm) farmer welfare. To pursue these goals, he is defining a model for food loss and farmer welfare. The definition of the model benefits from many hours spent collecting data via surveys and from talking and walking among growers, buyers, and government officials in India. He has developed an in-depth understanding of the setting. An initial model has been developed, and he is in the process of refining the model and testing with preliminary calibrations. After a model and calibration are in place, he will examine the impact of policy interventions that affect parameters in the model. He is making steady progress and I expect he will obtain interesting results.

Alwin is a pleasant person. He always has a smile, and I see that he gets along well with his fellow students. I expect that he is an effective teacher.

He is an active and productive researcher, having published many papers and presented at many conferences during his brief time as a student. He has a diverse methodological skill set, strongest in empirical methods and with a good understanding of analytical methods. He has a very good understanding of, and connections to, agricultural challenges in India.

I strongly recommend Alwin for your position. He will be a positive addition—as a colleague, teacher, and researcher—to any faculty.

Sincerely,

Professor and Bob Herberger Arizona Heritage Chair in Supply Chain Management

[1] Belavina E, Kabra A, Girotra K (2017) Online grocery retail: Revenue models and environmental impact. *Management Science* 63(6):1781-1799 [full class period of 3 hours]
de Zegher JF, Iancu DA, Lee HL (2019) Designing contracts and sourcing channels to create shared value. *Manufacturing & Service Operations Management* 21(2):271-289. [full class period]
Chen YJ, Tang CS (2015) The economic value of market information for farmers in developing countries. *Production and Operations Management* 24(9):1441-1452. [one-half class period]

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**Assessing Post-Harvest Losses Under Vertical Coordination:**
**Evidence from an Emerging Economy**


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**Assessing Post-Harvest Losses Under Vertical Coordination: Evidence from an Emerging Economy**

*Abstract*

Developing and emerging economies (DEE) face significant food losses (FL). Most of the FL occurs during the post-harvest stages of food production. Vertical coordination is taking roots in many DEE and have claimed that contract farming (CF) can reduce FL. In this study, we model and measure the impact of CF on post-harvest losses (PHL) on smallholders' profits. We use a fuzzy regression discontinuity (FRD) method and farm-level data from okra farmers in India. Results show that okra growers under both production and marketing contracts have higher profits and higher PHL than independent okra growers. Specifically, PHL was about 53% for okra growers with production contracts (PC) and 26% for okra growers with marketing contracts (MC). However, much of the PHL originated from rejected quantities from contracting firms. We tested that under 5% rejection rate we find that PHL under PC and MC were reduced considerably (87% and 64%) compared to the business-as-usual scenario. Finally, PC growers received higher profits and lower PHL compared to MC growers.

***Keywords:*** Vertical coordination, production contracts, India, post-harvest losses, food loss, emerging economy, fuzzy regression discontinuity

***JEL Classification:*** C31, D23, Q12

## Introduction

Food loss is substantial in developing, and emerging economies and post-harvest losses (PHL) account for a significant proportion of food loss. In countries like Egypt, Venezuela, India, and Indonesia, the post-harvest losses are about 30-40 percent. In developed countries, PHL is significantly lower, about 9-12 percent (Hodges, Buzby & Bennett, 2011). The PHL may occur because of a lack of infrastructure (storage and warehousing) and lack of proper transportation and marketing facilities. Other losses occur when suppliers reject the produce due to poor quality or failure to comply with their minimum quality standards of acceptance. This type of loss may occur in the vertically coordinated (or contract farming) farming sector. Contract farming (CF)[1] claims to reduce market failures and increase efficiency in the production system and the value chain. CF

[1] CF is defined as a way of producing food according to the mutually agreed provisions in the contract, which includes pre-agreed price, quality, and quantity of produce and time of delivery (Eaton and Shepherd, 2001). Furthermore, CF reduces uncertainty relating to the quality and quantity of supply (Hobbs & Linda, 2000).

also has been observed to bring about better coordination among the downstream stages of the supply chain, reduce transactions costs, and increase efficiency (Gray & Boehlje, 2005). Finally, CF has proven to have positive impacts on yield and income (Wang & Delgado, 2014; Ramaswami, Birthal and Joshi, 2006; Mishra et al., 2016, 2017, 2018a, 2018b, 2018c, ). A few studies provide some insights into the efficient functioning of CF, but CF's impact on food losses is yet to be analyzed.

In CF, the contracting firm employs extension agents who communicate the requirements of the firm (contractor), provide expert information, and supervise growers' behavior (Bellemare, 2010). Thus, monitoring and supervision by firm-employed extension agents may help reduce PHL. On the one hand, CF may help reduce PHL because the contractor provides post-harvest services (transportation, grading, storage, and marketing). On the other hand, CF may increase PHL because contractors tend to reject produce that does not meet the required quality standards. To this end, literature falls short of addressing the issue of PHL under vertical coordination. This study considers whether institutional arrangements such as CF can bring about a reduction in food losses (i.e., PHL) in the supply chain. Specifically, we compare PHL under production contracts (PC) and marketing contracts (MC) with PHL under independent (IF) okra producers. In the case of India, PHL in okra is estimated to be about 29-31 percent (WFLO, 2010). However, the magnitude of PHL depends on the form of farming arrangement. Any reduction in food losses, especially PHL, could lead to greater food availability and increased food security and contribute to the United Nations' sustainable development goal of reducing food losses in the supply chain.

Hence, this study's objective is threefold. First is to measure the impact of CF (PC and MC) on PHL compared to the PHL of IF okra[2] farmers. Second is to measure the impact of CF

[2] Okra is considered because it is a highly perishable commodity with a shelf life of just 6 days (Hailu & Derbew, 2015). Okra (*Abelmoschus esculentus)* is a vegetable grown in tropical countries, particularly in India, Nigeria,

(PC and MC) on profits compared to the profits of IF okra farmers.The third is to use the results to provide guidance to policymakers in designing policies to increase the profitability of small marginal growers and to reduce PHL along the supply chain. In India, okra is cultivated under PC, MC, or IF. Under PC and MC, growers sell their okra produce to the contracting company; under IF, growers sell in spot markets. The distance from the grower's field to the contractor's collection center is the variable of interest in this study because contractors provide contracts based on the location of the contracting firm (collection centers). In the case of okra, PC and MC are provided to growers whose fields are located within 5 km (3.10 miles) and 18 km (11.18 miles), respectively, of the contractor's collection center. The decisions on the cut-off distances (5 km and 18 km) are exogenous to growers and are made by the contracting firms. The distance cut-offs of 5 km and 18 km allow us to analyze the treatment effects under a regression discontinuity framework. Using survey data from more than 660 growers, we compare the magnitude of PHL and profits separately for PC and IF and for MC and IF. Two separate analyses are performed because PC and MC okra growers are not clustered in the same location.

The study finds that, compared to IF okra growers, okra growers with PC and MC earn higher profits, but the magnitude of profits differs by farming arrangement (PC and MC). We also find that both PC and MC growers have higher PHL than IF growers. This may be counterintuitive given that PC and MC growers are more efficient than IF growers in the production, harvest and transportation stages. However, PC and MC growers face significant rejections of the quantity harvested because of failure to comply with minimum acceptance standards, contributing significantly to PHL. Nevertheless, for further analysis, we allowed for a 5 percent rejection rate

Pakistan, Cameroon, Iraq, and Ghana. It is consumed all over the world because it is rich in Vitamin A, folic acid, carbohydrates, phosphorus, manganese, and potassium. India ranks first in the production and contributes to almost 61.9% of the world's okra production (FAOSTAT, 2016).

from PHL and re-estimated the treatment effects. We found that not only were profits higher, but PHL was significantly lower, too, for both PC and MC growers compared to IF. This is attributed to the quantity that was previously rejected now is accounted for in sales. However, negligible rejections are not practically possible, but measures need to be taken to reduce the magnitude of rejections.

The article is structured as follows. Section 1 provides the background on PHL and CF. The section concludes with this study's contribution. Section 2 discusses the methodology used and the data source. Section 3 elaborates on the identification strategy used under the framework in regression discontinuity design. Section 4 discusses the outcomes of post-harvest losses and profits for PC, MC, and IF. A similar analysis was done, considering a 5 percent rejection component. Discussion and conclusion sections follow.

## Literature Review

### *Contract farming and post-harvest losses*

PHL in horticultural crops occurs after harvest and before consumption. Developing countries suffer from the lack of adequate marketing systems, which is further accentuated by the lack of market information and poor communication between producers (growers) and contractors. Traditional spot markets lack facilities for efficient loading, unloading, ripening, packaging, and short-term storage. Furthermore, the lack of adequate transport facilities for perishables leads to higher deterioration rates, which decreases the quality of the produce. A recent study by Hengsdijk & Boer (2017) concludes that a negative and signficant relationship exists between PHL and the rural household's distance to the nearest market or nearest road. On the other hand, government regulations in the form of price controls have been found to increase PHL (Kader, 2005; Balaji & Arshinder, 2016). Though price controls are intended to protect consumers, they led to black marketing and reduced the incentive to produce high-quality produce. The above contraints have led to higher PHL among IF of perishable products. In a recent study, Gardas, Raut & Narkhede (2018) evaluated critical factors affecting PHL in the fruit and vegetable value chains in India. The authors concluded that the lack of proper packaging, inadequate infrastructure, and poor handling of products at the farm and spot markets were the main reasons for high PHL. Futhermore, they argued that strong linkages between growers, processing units, marketing channels, and intermediaries were significant in understanding the mechanisms of PHL.

Management of perishables such as fruits and vegetables throughout the value chains is highly complex and risky. Due to seasonality and supply spikes, efficient management becomes significantly difficult (Behzadi et al. 2018). Recently, a different type of strategic alliances of vertical coordination (such as a contract) with supply chain partners have begun to emerge (Coase, 1937; Williamson, 1979). This could enhance the sharing of accurate information, better supplier-retailer relationships, and transparency among food supply chain members. Furthermore, collaborations across different supply chain actors may be possible, which could result in reducing transaction costs and eventually PHL (Despoudi et al. 2018; Gray & Boehlje, 2005). Recently, Despoudi et al. (2018) tested the collaborative supply chain among Greek peach producers and concluded that collaboration among the supply chain actors reduces PHL and enhances business performance. The tight linkage or collaboration has helped enhance the quality of produce through the transfer of information (Hobbs & Linda, 2000; Hennessy & Lawrence, 1999). Similarly, in the developing countries context, Singh (2007) concluded that CF might lead to better supply chain management[3] among growers of organic basmati rice, potatoes, and mint in India. Furthermore,

[3] CF creates an environment of innovation and coordination.

under CF, a contractor's logistical capacity can generate economic gains, thereby increasing savings and efficiency of the value chains (Kaufman et al. 2010; Barrett et al. 2012; Wang, Wang & Delgado, 2014).

Another strand of literature on planning models concludes that integration of harvesting, processing, and other inventory control issues may lead to a significant reduction in PHL and enhance the quality of the produce (Kusumastuti, Donk & Teunter 2016; Bellemare, 2010; Tsolakis et al. 2014; Zanoni & Zavanella, 2007). For instance, Kusumastuti, Donk & Teunter (2016) argue that coordination between different actors in the harvesting to processing stages is particularly needed in the case of perishable commodities. After harvesting, the perishable crop undergoes metabolic activities leading to physiological changes that deteriorate the quality and quantity of the produce. Therefore, close coordination between the stages of harvesting and processing is needed to minimize losses. Close coordination between the growers and contractor also is ensured through monitoring and supervision by the contractor's technical assistants. They visit growers, provide them information about seeds and fertilizers, and ensure that they follow the production schedule. This positively impacts the yield and quality of produce (Bellemare, 2010).

According to Tsolakis et al. (2014), one component in the decision-making process in agrisupply chains is the planning of logistics operations. These decisions include logistics operations such as unitization of goods, packaging, stacking, building, wrapping, unstacking, and inventory control. The efficiency of the transport system[4] is also integral to the process (Zanoni & Zavanella, 2007). The objective of this process is to provide consumers with a superior-quality product at the least cost and in compliance with established safety regulations. Finally, Higgins et

[4] The objective is to minimize supply chain inventory and the transport costs.

al. (2004) found that integrating harvesting and transport facilities across the value chain could increase the profitability of Australian sugar cane farmers by about AU$1 million per year.

Apart from the above sources of PHL, minimum quality standards also may contribute significantly to PHL. Minimum quality standards for produce are necessary to comply with food regulations (such as restricted use of pesticides and child labor or residue limits to hygiene and traceability, Miyata, Minot and Hu, 2009) and to reduce risks pertaining to elongated supply chains (Lee, Gereffi and Beauvais, 2012). Elongated supply chains may expose perishable produce to a greater risk of contamination. Therefore, it becomes incumbent upon the contractors to adhere to these standards. Further, these quality standards are paramount in gobal supply chains. These minimum quality standards may act as a catalyst and result in growers upgrading their production system, or, alternatively, they may act as a barrier and result in downgrading and exiting from production. For example, Jaffee (2004) found that growers who complied with standards increased their incomes. Note that compliance with the standards may require greater financial, informational, and network resources. However, given that small and marginal growers lack sufficient resources, they are squeezed out of the process (Ollinger, Moore and Chandran, 2004; Henson and Humprey, 2009). The magnitude of compliance depends on whether contractors provide any assistance to growers in the form of information and financing. This, in turn, depends on the terms of the contract. Compliance also depends on growers' willingness to invest in higher-quality production.

Since PC and MC have different terms and contractual obligations, they are likely to have different impacts on PHL. For instance, under PC, contractors are expected to better manage the stages of transportation, storage, processing, packaging, and marketing. Since the contractors come directly to the grower's field to get the produce, the distance the growers cover is negligible. Under

MC, growers are responsible for transporting the produce to the contractor's collection center. Due to lack of resources and greater distances covered, compared to growers under PC, there is a possibility of higher PHL. In other words, MC growers lack information or resources to conserve the perishables' quality. However, the distance the produce travels to the terminal market is much shorter under MC than under the IF farming arrangement. Apart from a distance, growers under IF lose some produce in the spot market due to improper infrastructure and poor handling. In short, CF brings about coordination and transparency in the value chains and thereby reduces transaction costs and inefficiencies. As a result, CF may help reduce PHL. However, in CF, the minimum standard for the produce as dictated by the contractors offering PC is strict and relatively higher than the minimum standard for the produce offered in MC. This is because PC contractors have positioned themselves in export markets, and contractors offering MC sell their produce in the domestic market. Hence, minimum quality standards may impact the magnitude of PHL adversely if growers are unable to comply with them. Therefore, we can conclude that the magnitude of PHL depends on the form of contractual obligations and control of value chain actors.

*Okra farming in India*

In 2016, India produced approximately 6 million tons of okra. With close to 500,000 hectares, India's yield was ranked 12$^{th}$ among the countries known for okra production. Lower yield could be due to inefficient production or to poor post-harvest processes. Short shelf life and inefficient post-harvest stages for okra have resulted in high PHL. The major source of PHL is water loss and decay during transportation and storage. Okra is also a labor-intensive crop that needs harvesting every two days during the harvesting season. Labor costs constitute almost 37% of the total cultivation expenses. The attributes important for quality standards in okra are length, firmness, color, and girth. The minimum quality standards require that okra be be less than 3 inches in length.

Consumers and contractors also consider color, girth, and firmness in assessing the quality of okra. Lack of firmness, the presence of yellow patches, or pods of more than 3 inches may lead to rejection. The high quality of okra depends significantly on production and harvesting decisions. Since harvesting operations are mostly labor intensive, lack of labor can significantly reduce the quality of okra. For instance, lack of labor may lead to oversized (greater than 3 inches) okra, or improper harvesting may damage the produce.

The state of Karnataka in India is where we conducted our survey.[5] The state is popular for okra cultivation and among the top states producing okra. In this state and districts, contractors with PC and MC require that okra be sorted and placed in boxes before being transported. Doing so reduces the damage to okra during transportation and hence preserves quality. However, IF producing okra have to suffer losses in multiple stages of the supply chain. For example, damage to okra can result from improper packing, long transportation distances, and poor unloading practices at the spot markets. In the case of IF, okra is packed in jute bags and unloaded manually by unskilled laborers in the spot markets. Moreover, during the selling process, a share of okra is damaged or lost due to mishandling. The selling process happens through auctioning, where the bid depends on the average quality of okra in the consignment. However, no produce is rejected.

## Data

This study uses data from a primary survey. The survey data includes 660 okra growers: 420 okra growers in CF (210 with PC and 210 with MC) and 240 independent okra farmers (IF). Okra growers were sampled from two districts (Belgaum and Mysore) known for okra production in the state of Karnataka, India. The sample growers were selected through multi-stage sampling. In the

[5] Two other studies, Sudha, Gajanana & Murthy (2006) and Manjunatha & Venuprasad (2012), used sample of farmers in Karnataka. Sudha, Gajanana & Murthy (2006) and Manjunatha & Venuprasad (2012) okra seed producers under contract have higher yield and income, compared to independent okra seed producers.

first stage, based on the area of okra cultivation, districts of Belgaum and Mysore were selected. In the second stage, villages participating in PC and MC were randomly selected. Thereafter, growers[6] participating in PC, MC, and IF were randomly selected based on the threshold/cut-offs decided by the contractors. In this study, PC and MC contractors respectively use the thresholds of 5km (3.10 miles) and 18 km (11.18 miles). The PC and MC contractors depending upon the scale of operations exogenously decided these thresholds. The random selection of growers on either side of the threshold was done so that there is an equal probability of being chosen for sampling both inside and outside the threshold. In the sample design, PC and MC growers were located in the Belgaum and Mysore districts, respectively (figure 1). This could be due to a policy or conditions favoring a single CF channel (PC or MC). Given this scenario, PC (210) and IF (120) growers were sampled together, and MC (210) and IF (120) growers were sampled together.

The study collected information on the 2017-18 cropping season. Okra farmers were queried on socio-economic variables such as education, caste, and a number of family members, and on variables related to okra production, including quantity produced, quantity sold, land size, harvesting stages, transport cost, storage cost, contractual terms, and rejection rates. Data on risk aversion also was collected. Table 1 provides the summary statistics of the survey data. Notice that okra growers with PC and IF in the Belgaum district seem to be similar in most of the covariates. However, okra growers with MC and IF in the Mysore district are considerably different. Profits and PHL for both PC and IF and for MC and IF with rejection clause and 5% rejection clause are statistically different for both groups.

[6] A census was carried out in villages to locate the PC, MC and IF growers. For every km both within and outside the threshold the proportion of growers in PC, MC and IF were listed. Within this list, growers were randomly chosen for the survey.

In this study, PHL is defined as the difference between the quantity harvested and the quantity sold. Figure 2 shows the different stages after harvesting where PHL happen for PC, MC, and IF growers, respectively. To corroborate the data on PHL, we used the data on quantity lost in different stages, such as due to rejections, transportation, or handling, and at the contractor's collection center or at spot markets. However, not all rejected quantity was considered PHL. Note that in some cases, okra growers find it feasible to sell the rejected quantity in spot markets. This is the case when the quantity rejected is significant enough to make it feasible to transport the produce to spot markets. However, selling to spot markets also leads to losses during transportation, handling, and it incurs additional transportation costs. However, the rejected okra not sold in the spot market ends up as cattle feed or is left in the fields. In both cases, it is considered PHL. Rejections are generally a concern for okra growers in CF with PC and MC. Rejection is not an issue with IF as there are no minimum quality standards in spot markets (See figure 2).

Regarding the loss during transportation, approximations are considered depending upon the distance travelled and the quality of containers (jute bags vs. boxes). As per interviews with the aggregators,[7] losses for produce transported in jute bags of 50 kg are about 4 percent for distances less than 30 km and about 5 percent for distances less than 50 km. Losses for produce transported in boxes were smaller, around 2 percent, regardless of the distance travelled. A fixed rate of produce loss during handling (loading/unloading) is considered, regardless of whether the okra was sent to collection centers (MC) or sold in spot markets. Information about the quantity lost in the loading/unloading stage was obtained from field interviews in spot markets and with managers at collection centers. According to them, losses during loading/unloading and at the spot

[7] Those who are responsible for transporting the produce from grower's field to spot market/collection centers.

market averaged around 4–5 percent. Figure 2 shows the stages where PHL is observed among okra grower with PC, MC[8] , and IF.

**Empirical Framework**

As previously mentioned, growers within proximity to the contractor's collection center were more likely to receive PC or MC than growers farther from the center. This provides the opportunity for the use of regression discontinuity design (RDD). Though there are a number of quasi-experimental methods such as propensity score matching (PSM), endogenous switching regression, the difference-in-difference, and 2SLS IV, which have been used in similar contexts, very few, have used regression discontinuity design. This could be attributed to the assignment variable, which is difficult to identify. The assignment variable should not be influenced by the observations, and it should have a threshold to differentiate between the treatment and the control group (Hahn, Todd & Klaauw, 1999; Campbell, 1963). The advantages of RDD over other quasi-experimental methods such as instrumental variables and difference-in-difference is that RDD allows the researchers to identify the causal effect without imposing arbitrary exclusion restrictions. RDD does not need defining functional forms or distributional assumptions on errors. Under the weak assumption, the probability of receiving the treatment close to the cut-off is considered random (Hahn et al. 2001). Lee (2008) showed that there is no need to assume that RDD design isolates treatment variation; instead, it is the result of the agents' inability to precisely control the assignment variable close to the cut-off distance.

The RDD method provides a more credible and transparent way of estimating the impact of any program or policy (Lee, 2010). To estimate the RDD model, researchers need to fulfill three

[8] MC growers rarely know the buyer of their produce during production. Few days before harvesting, the MC contractor informs MC growers about their intention to buy the produce given that they fulfill the minimum requirement. Rest of the produce is sold directly to the spot markets.

pre-conditions (Cerulli, 2015). First, the assignment variable needs to be "non-manipulated." Non-manipulation here means that growers are not able to change the value of the assignment variable to benefit from the change of position around the cut-off. Second, the assumption of quasi-randomness needs to hold at the threshold. In other words, there need to be no significant differences in the attributes of growers to the left and right of the threshold within the selected bandwidth. Third, the assumption of the continuity of the outcome variable(s) at the threshold needs to hold.

The first pre-condition needs a specification of the assignment variable. The assignment variable has to be exogenous in nature. Recently, Pan, Smith, and Sulaiman (2018) used the distance between the extension center and the farming household as the running or assignment variable. In their study, distance-to-branch threshold was used as an eligibility criterion for the village program. Those farmers who were eligible were found to use better cultivation methods and had less food insecurity than farmers located farther from the center. In another study, Black (1999) used the distance to the district boundary as an assignment variable to measure the causal impact of housing prices and test scores.[9] In our study, the assignment variable ($x_0$) is the distance between the grower and the contractor's collection center. Distance is one of the main eligibility criteria depending on which contractors offer contracts (PC and MC) to the growers. According to the field research, the contractors provide PC to smallholder households under 5 km (3.10 miles); for the MC, the cut-off lies under 18 km (11.18 miles). These cut-offs are decided by the contractors depending on the integration and scale of operations. The PC is relatively more integrated, as all operations from production to marketing of okra are closely coordinated,

[9] Houses close to the district boundary had similar attributes but had access to different elementary school leading to different learning outcomes; in this case, the test scores. The study concluded that parents were willing to pay almost 2.5 percent more for houses for a 5 percent increase in the test scores.

compared to MC and IF. The MC is partially integrated because only marketing operations are carried out by the contractors. The variation in the magnitude of integration explains the differences in the cut-offs. Moreover, these cut-offs are exogenously determined by the contractors, and growers cannot manipulate them for two reasons. First, growers are not aware of such distance cut-offs. Second, purchasing land to become eligible for the contract, though seemingly plausible, is highly unlikely as land prices are too high for okra growers in the region. Moreover, the density smoothness test proposed by McCrary (2008) failed to reject the smoothness of grower's density[10] at the cut-offs. Finally, figures 3 and 4 show that the histogram of the distribution of the assignment variable at the threshold is continuous. These provide evidence that growers cannot manipulate the assignment variable.

For the second pre-condition of the assumption of quasi-randomness, we compared the attributes of growers to the left and right of the cut-off within a specified bandwidth for both districts. The sample of growers in our study is distributed between the two districts of Belgaum and Mysore. In Belgaum, we compare PC and IF growers; in Mysore, we compare MC and IF okra growers. For PC and IF in the Belgaum district, we considered a bandwidth of 1 km and 1.20 km to the left and right of the cut-off of 5 km, respectively. Similar bandwidth is chosen for MC and IF in the Mysore district. Table 1 shows that the means of age, land size, caste, water quality, distance to road, higher and tertiary educational levels, number of plots owned, dependency ratio, number of years of farming, and distances to cooperative society, bus station and irrigation source were similar among growers on both sides of the cut-off in both districts. In other words, there is no significant difference between the two groups on either side of the cut-off. This satisfies the second precondition of quasi-randomness at the threshold.

[10] This provides evidence of the "non-manipulation" of the assignment variable.

Finally, we provide evidence that the assumption of continuity of the outcome variables, i.e., profit and PHL per acre, hold at the threshold. Figures 5 and 6 show that distribution of the outcomes for respective growers. The distribution is seen to be similar and overlapping, suggesting the assumption of continuity of outcome variable holds. In our case, a fuzzy regression design (FRD) is used because we have independent okra growers farming within 5 miles[11] (figure 3) along with okra growers with PC in one of the districts. A similar case is observed between MC and IF growers in another district (figure 4).

*Fuzzy Regression Design*

Imperfect compliance means that even if eligibility for treatment (PC or MC) is determined by the cut-off rule, not all eligible candidates may obtain/accept the treatment (Lee and Miller, 2007). Moreover, the probability of receiving the treatment does not change from zero to one at the threshold. However, a milder jump in the likelihood of assignment to the treatment group at the threshold is observed. Therefore, a fuzzy RDD procedure is used and follows the structure below. Let us define a linear probability model on the left and right side of the threshold as:

$$\begin{aligned} \Pr\left(W_i = 1 \mid X_i = x_0\right) &= \phi_L + \pi_L\left(X_i - x_0\right) \\ \Pr\left(W_i = 1 \mid X_i = x_0\right) &= \phi_R + \pi_R\left(X_i - x_0\right) \end{aligned} \tag{1}$$

One can estimate both regressions in equation 1 via a single pooled regression:

$$\Pr\left(W_i = 1 \mid X_i = x_0\right) = \phi_L + \left(\phi_R - \phi_L\right)*T_i + \pi_L\left(X_i - x_0\right) + \left(\pi_R - \pi_L\right)*T_i\left(X_i - x_0\right) \tag{2}$$

where $W_i$ is the treatment variable (PC or MC) and $X_i$ is the assignment variable (distance between grower's field and contractor's collection center) with $x_0$ as the threshold or cut-off. In the case of FRD, $W_i \neq T_i$ because of incomplete compliance and a result $T_i = 1\left(X_i > x_0\right)$. A parametric approach (Imbens and Lemieux, 2008) can be implemented to estimate our empirical model; the process

[11] In other words, there are cases of imperfect compliance on one side of the cut-off.

requires two steps. First, estimate the discontinuity consistently in the probability (getting treated by PC or MC) at the threshold as the distance between the two intercepts of the right and left regression, is obtained as the coefficient of $T_i$. The OLS regression is represented as:

$$W_i = \phi_L + (\phi_R - \phi_L) * T_i + \gamma_L (X_i - x_0) + (\pi_R - \pi_L) * T_i (X_i - x_0) + \eta_i \quad (3)$$

Second, estimate the discontinuity consistently in the outcome (profit and PHL) at the threshold as the distance between the two intercepts of the right and left regression, as the coefficient of $T_i$.

The OLS regression is represented as:

$$Y_i = \alpha_L + (\alpha_R - \alpha_L) * T_i + \gamma_L (X_i - x_0) + (\gamma_R - \gamma_L) * T_i * (X_i - x_0) + \varepsilon_i \quad (4)$$

Since the probability of treatment jumps by less than one at the threshold, the jump in the relationship between outcome variable (*Y*) and the assignment variable (*X*) can no longer be interpreted as average treatment effct (ATE). As in the case of the instrumental variable (IV) setting, the treatment effect can be recovered by dividing the jump into the relationship between outcome variable (*Y*) and *X* at $x_0$ by the fraction induced to take up the treatment at the threshold to calculate the ATE. Finally, ATE is estimated as:

$$\text{ATE}_{FRD} = \frac{\widehat{\alpha}_R - \widehat{\alpha}_L}{\widehat{\phi}_R - \widehat{\phi}_L}.$$

*Alternative Specifications*

In this study, we use a quadratic form of FRD and control for covariates such as age, farm size, a caste of the farm family, educational attainment, number of plots owned, dependency ratio, years of farming, and distances to a cooperative society, roads, nearest bus station, and irrigation sources. Additionally, an asymptotically optimum bandwidth is derived from minimizing the mean square errors. Following Li (1987) and Imbens and Kalyanaraman (2012), the selection of the bandwidth considers the features of RDD and is primarily driven by the data. Moreover, in our case, to check for sensitivity, the bandwidth was increased by 100 meters to the right side of the cut-off. As a result, a 100-meter increase in the bandwidth increased per-acre profit by 5 percent. Given that the outcome variable (profits) did not increase at a significant rate, it can be concluded that the estimates are stable. Finally, a quadratic form of a polynomial also is considered, and we found that local linear RDD was not able to capture the variability at the cut-off. A higher-degree polynomial was not chosen because it tends to provide noisy estimates, too sensitive to the degree of the polynomial used and poor coverage of confidence intervals following Gelman and Imbens (2017). However, for robustness, the age of the operator variable was dropped from the list of covariates, and the FRD was re-estimated. The estimates did not change significantly.

**Results**

*Impact of CF on profits (business as usual)*

Table 3 and 4 present the estimates of adoption of PC and MC, respectively, on profits on okra farming in India. Recall that the model was estimated separately for PC and IF in the Belgaum district and for MC and IF for the Mysore district. The impact of the threshold distance between the grower's field and the contractor's collection center in both PC and MC on adoption is negative and statistically significant at the 5% and 1% levels, respectively (tables 3 and 4, column 1). In other words, okra growers located closer to the contractor's collection center are more likely to adopt PC (if the farm is located in the Belgaum district) or MC (if the farm is located in the Mysore district) than growers located farther from the center. With respect to outcome variables[12], profits per acre, okra growers with PC[13] earn significantly more, about 101%[14] (Rs.12,212 or $174.96,

[12] The regression results for the whole sample were also run using endogenous switching regression. The results have not been presented due to brevity. It can be shared on request.
[13] Note that contractor's cut-off distance is 5km for PC and 18km for MC.
[14] We consider bias-corrected results.

table 3, columns 2 and 3)[15] than their counterparts (IF) in the Belgaum district. Similarly, okra growers with MC earn significantly more, about 40% (Rs. 5,964 or $85.44, table 4, columns 2 and 3) than their counterparts (IF) in the Mysore district. For the robustness test, we selected bandwidth of 1 km to the left and 1.20 km to the right of the cut-off (see figures 7 and 8). The selected bandwidth is found to be optimum given the data. Figures show that profits for okra growers with PC and MC were higher and statistically significant at the 10% and 5% levels, respectively than profits for IF growers. Moreover, figure 7 shows that profits tend to decrease as distances increase between the grower's field and the contractor's collection center. This may be due to the reduced quality of okra due to delays in picking and hauling produce from okra growers located closer to the cut-off distance. A similar trend is observed among okra growers with MC, though not that sharp. Higher profits for okra producers with PC and MC than for IF okra producers can be attributed to the higher price, on average that contracted okra growers receive and the higher output they realize due to better inputs and cropping information (agronomic, fertilization) provided by the contractor's extension agents.

*Impact on PHL (business as usual)*

Let us turn our attention to PHL. The estimates are presented in tables 3 and 4 (columns 4 and 5). Table 3 and figure 9 reveal that PHL is higher, about 53% (110 kg/acre) for okra growers with PC than for IF okra growers in the Belgaum district. Similarly, table 4 and figure 10 show that okra growers with MC have higher PHL of 26%, or about 72 kg/acre than IF okra growers in the Mysore district. However, the estimates of PHL for okra producers with PC and MC compared to IF okra producers were statistically insignificant. Figure 10 shows that PHL is higher for okra producers with MC, who are located closer to the cut-off distance. Findings here may be due to the distance

[15] $1 US = Rs. 69.80 (accessed on 3/11/2019).

between the grower's field and the contractor's collection center. Recall that in the case of MC, growers need to transport the produce from their field to the contractor's collection center—through an aggregator. Given that the growers at the cut-off distance are located about 16-18 km from the contractor's collection center, it may have an impact on the magnitude of PHL. Anecdotal evidence and field interview with the aggregator suggest that the operational cut-off is restricted to 18 km in order to reduce transport costs and losses occurring during transportation.

Our finding that PHL is higher though insignificant for PC and MC is interesting but puzzling. Based on the literature (see Kusumastuti, Donk & Teunter 2016; Tsolakis et al. 2014; Zanoni & Zavanella, 2007), okra growers with PC and MC are expected to have lower PHL than IF okra growers. Recall that post-harvest stages in the PC are managed by the contractors, and in the MC case, growers have to transport the produce a relatively shorter distance than IF okra growers. However, recall that the definition of PHL includes rejection quantities. The rejection is implemented for produce that does not meet the minimum quality requirement criteria set forth by the contractor. In the case of PC okra growers, contractors rejected an average of 301kg/acre; in the case of MC growers, contractors rejected an average 315kg/acre (table 1). In general, the majority of PHL came from the output rejected by contractors.[16] Large PHOL is concerning because okra growers are not able to capitalize on productivity and profits. Additionally, PHL in perishable commodities (such as okra) and in the presence of vertical coordination are avoidable.

In the following section, we estimate profits and PHL with a relatively lower rejection rate. We consider a 5% rejection rate[17], a reasonable assumption given that current rejection rates are

[16] In the case of PC, 99% of the PHL originated from losses dues to rejections (not meeting minimum quality requirements) by contractors. In the case of MC, 85% of the PHL originated from produce that was rejected by the contractor.

[17] Note that zero rejection rate is not practically feasible given the heterogeneity among growers. However, it can be minimized. 5% rejection rates are considered for those having higher than 5% as a rejection rate.

about 13% and 11% for okra producers with PC and MC, respectively. According to contractors engaged in PC and MC contracts, rejection rates have fallen considerably in the last couple of years, from a high of 30% to 15% in recent years. This is partly attributable to experience with CF and smallholders' initiative in "learning by doing."

*Impact of CF on profits and PHL, with a 5% rejection rate*

Table 5 reports the estimates of profits and PHL for okra growers with PC but facing a 5% rejection rate. Table 5 (columns 2 and 3) and figure 12 reveal that, with a 5% rejection rate, okra growers with PC receive profits about 120% higher (about Rs.14,575, or $208.81) than IF okra producers receive. Similarly, Table 6 (columns 2 and 3) and figure 13 reveal that, with a 5% rejection rate, okra growers with MC receive profits about 64% higher (about Rs. 9,680, or $138.68) than IF okra producers receive. Profits in both cases, CF with PC or MC, with a 5% rejection rate, are approximately 1.19 and 1.62 (=profits in 5% scenarios/profits in the business-as-usual model) times higher than in the business-as-usual model. Therefore, reducing the rejection rate to about 5% leads to higher profits, and the trend of profits moves closer to the cut-off (threshold) distance for both PC and MC growers.

Turning our attention to PHL under a 5% rejection rate, table 5 shows that PHL decreases by 91% or 186 kg/acre (see figure 14) for okra growers with PC compared to IF okra growers. Similarly, under a 5% rejection rate, table 6 (columns 4 and 5) shows that PHL decreases by 49% or 110 kg/acre (see figure 15) for okra growers with PC compared to IF okra growers. The PHL losses for PC and MC growers are statistically significant at 5%. Findings suggest that a 5% rejection rate helps lower the PHL for okra producers with PC and MC. A lower rejection rate leads to higher quantities acceptable to contractors, which in turn reduces PHL. In other words, lowering rejection rates could lead to lower food losses. However, reducing the rejection rate needs concerted efforts from both growers and contractors.

**Discussion**

This study investigated the impact of CF (PC and MC) on profits and PHL for okra, a highly perishable commodity. We used two scenarios to draw conclusions of CF on profits and PHL. The first analysis is done for the business-as-usual scenario, and the second analysis uses a 5% rejection rate. Under the business-as-usual scenario, the study reveals that CF (both PC and MC) leads to higher profits and higher PHL compared to IF okra producers. Further, we found that the rejection quantity (not meeting minimum quality requirements) was a major share of the PHL for both PC and MC growers. Findings here indicate that there is scope for improvement with regards to reducing the rejection rate by growers. In the second scenario, we use a 5% rejection rate, compared to a 15% rejection rate in the business-as-usual scenario. Under the 5% rejection rate scenario, profits were higher for okra growers with PC and MC, and PHL were much smaller than for IF okra growers. In other words, with a 5% rejection rate, PHL under PC and MC were reduced considerably (87% and 64%) compared to the business-as-usual scenario. This finding suggests that under a lower rejection rate, CF (PC and MC) increases profits and lowers PHL. However, future research needs to find the optimum rejection rate. A zero-rejection rate is not feasible, and a higher rejection rate would lead to greater PHL. Therefore, future research needs to address and understand the relationship between PHL and rejection rates.

According to figure 16, there is a threshold (ⲧ) rejection rate after which selling to spot markets becomes feasible. This is due to the costs related to transport, labor, and other administration. But this also entails some PHL, which increase if more output is sold in the spot market. However, if growers have a rejection rate below the threshold (ⲧ), the produce is either fed to cattle or left in the field, contributing significantly to PHL. An interesting point to be noted here is that the rate of increase in PHL is higher if the rejection rate is below the threshold (T). PHL is a result of inefficiencies in handling and transportation distances in a perishable commodity like okra. Therefore, the takeaway from this discussion is that CF reduces PHL, given that the rejection rates are considerably low. If the rejection rates are higher than the threshold, CF may lead to higher PHL. The optimum policy would be to reduce rejection rates and maintain them at the lowest level. We also find that PHL is higher among growers located closer to the threshold than for those located closer to the contractor's collection center. Note that the harvesting of okra is done every two days. Therefore, the distance between growers' fields and contractors' collection centers increases the risk of perishability. Findings suggest that distance between growers with PC and MC and contractors needs to be reduced, especially in the case of producers of highly perishable commodities. An effective way would be to operate in clusters rather than a stretch of long-distance operations. Finally, the above actions would lead to higher profits and significantly lower PHL.

## Conclusions

Developing countries have PHL amounting to 30-40 percent. Reducing PHL would lead to greater food availability and contribute to the United Nations' sustainable development goals. This study examines whether the adoption of CF can reduce PHL. In particular, the study examines the impact of the adoption of PC and MC contracts on PHL per acre and profit per acre in okra farming in India. Okra is a highly perishable crop with a shelf life of 6 days. Therefore, okra needs to be transported and loaded/unloaded within a short span with significant care. This requires efficient management of post-harvest stages to prevent losses. In this study, it was found that growers under PC and MC have higher profits but also have significantly higher PHL compared to IF growers.

However, the majority of PHL for PC and MC growers came from the rejected quantity. Next, it was found that, if rejection rates were reduced to as low as 5%, CF (both PC and MC) growers would not only increase profits but would reduce PHL. In particular, PC growers received higher profits and lower PHL compared to MC. Therefore, adoption of CF may lead to a reduction in PHL, given that rejection rates are significantly low. It also was observed that growers close to the threshold of 5 km for PC and 18 km for MC have higher PHL per acre than growers closer to the contractor's collection center. This could be due to the delay in lifting or transportation because of the distance. Moreover, since okra harvesting is carried out in multiple harvests, the distance may play a significant role. Therefore, reducing the operational range would greatly help reduce PHL.

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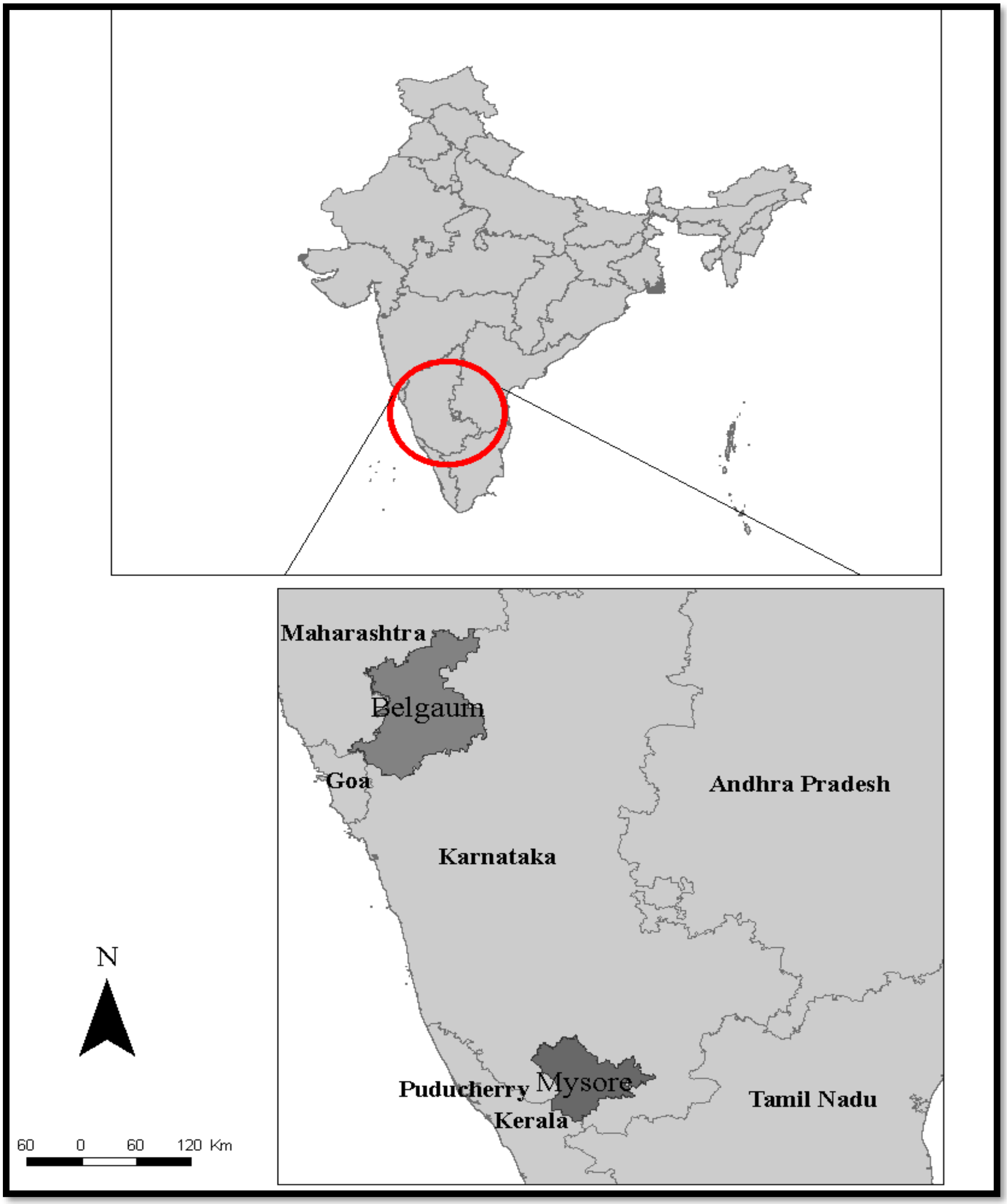



**Figure 1:** Surveyed districts of Belgaum and Mysore in Karnataka, India

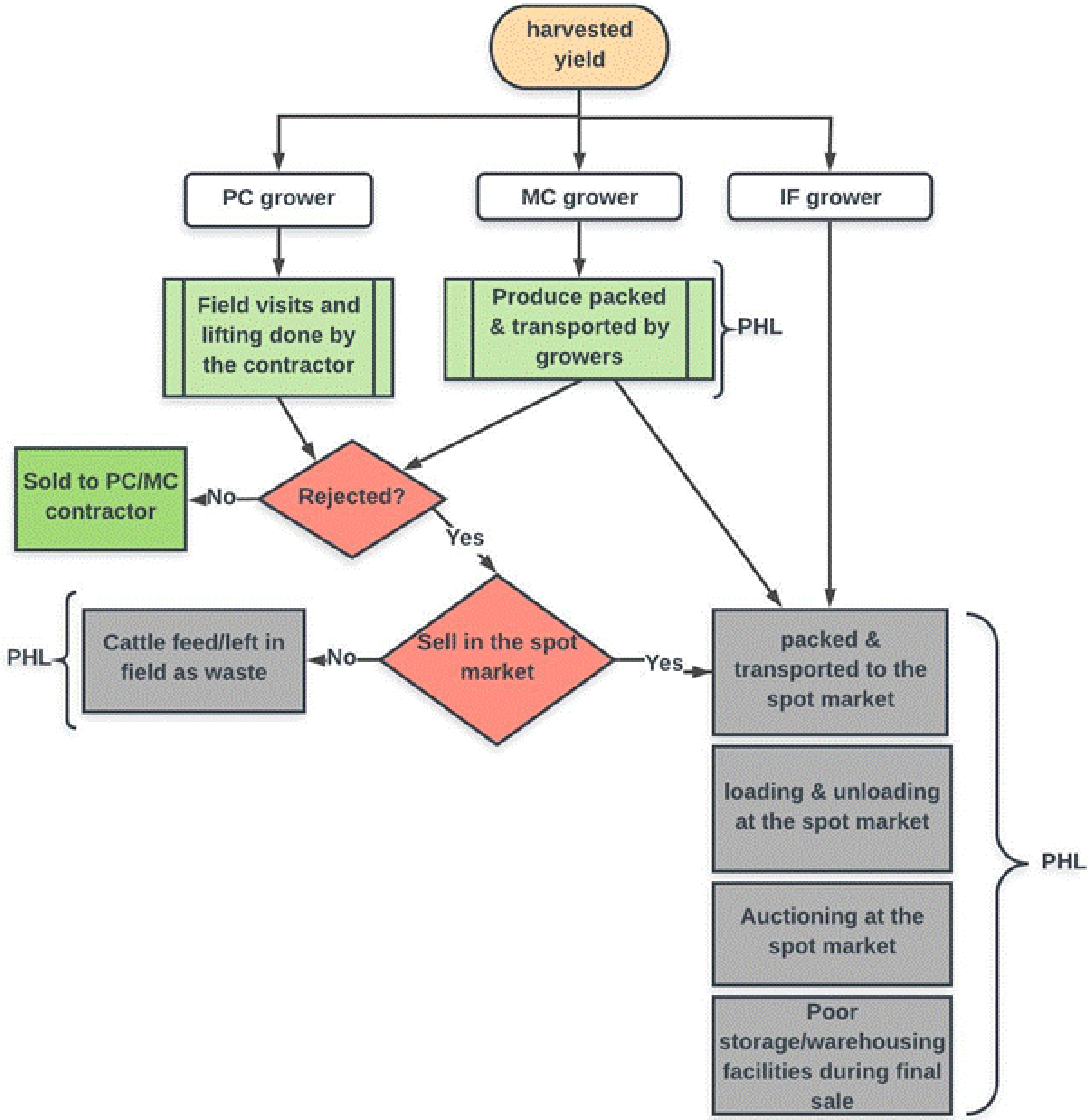



**Figure 2:** Supply chain model for PC and MC okra growers

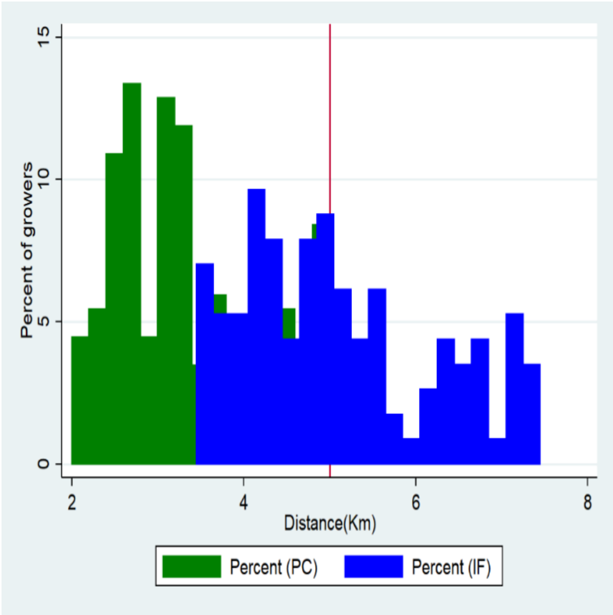



**Figure 3:** Distribution of PC & IF growers in the district of Belgaum

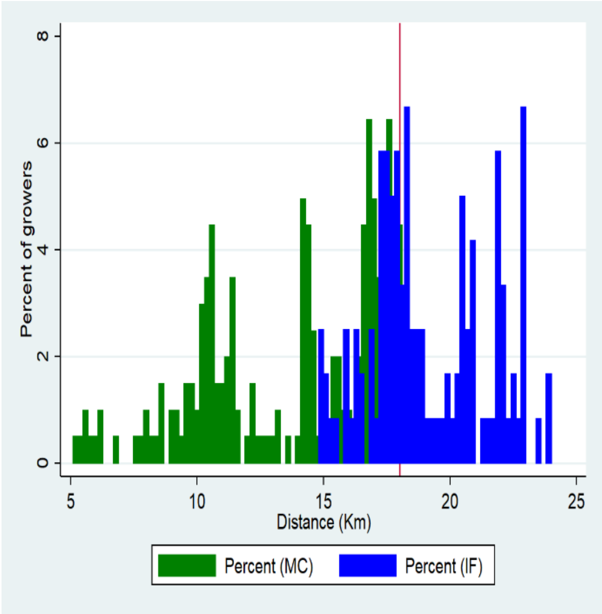



**Figure 4:** Distribution of MC & IF growers in the district of Mysore

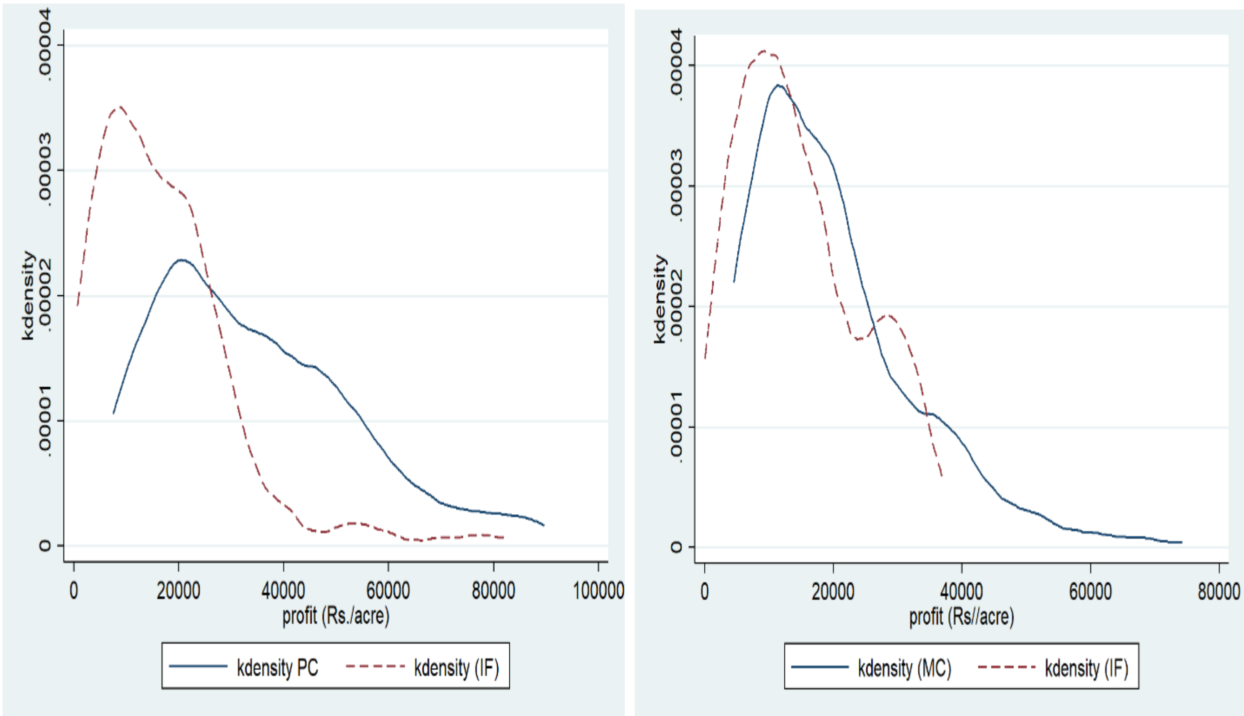



**Figure 5:** Overlapping distribution of profits and post-harvest losses for PC and IF, respectively

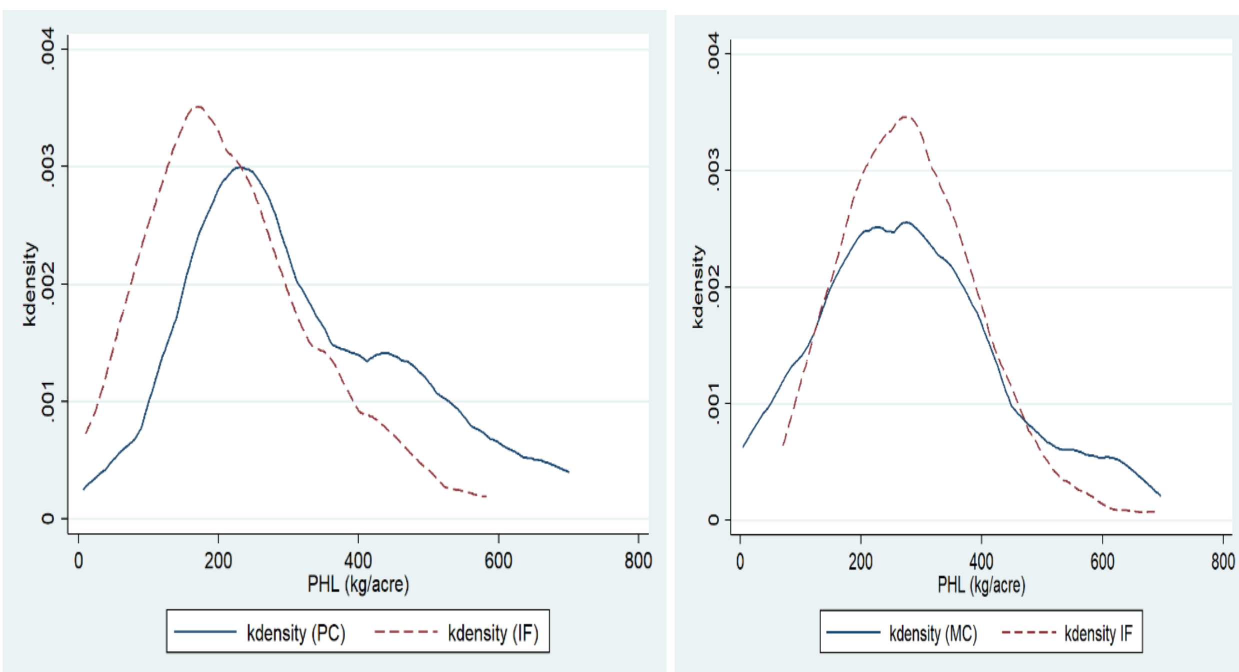
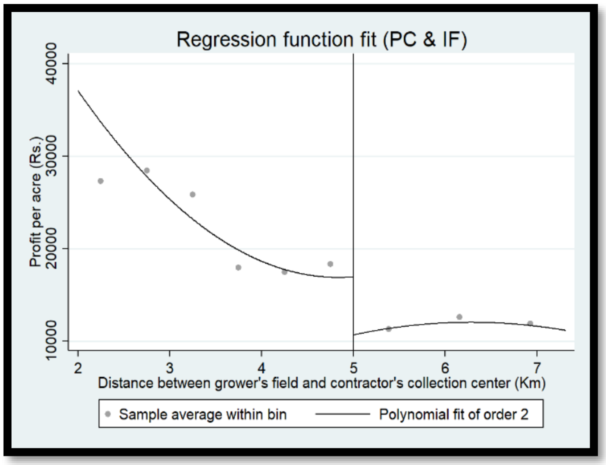



**Figure 6:** Overlapping distribution of profits and post-harvest losses for MC and IF respectively



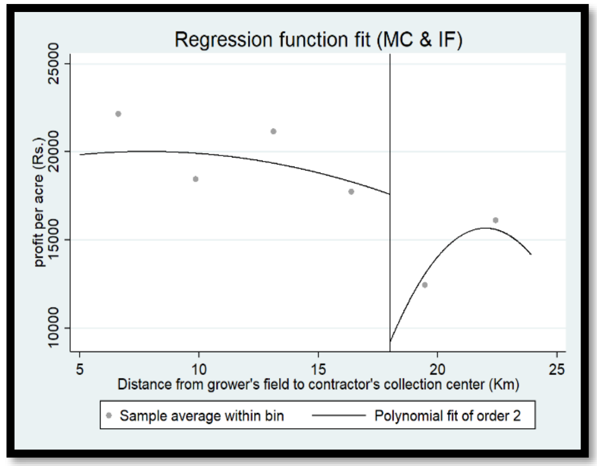
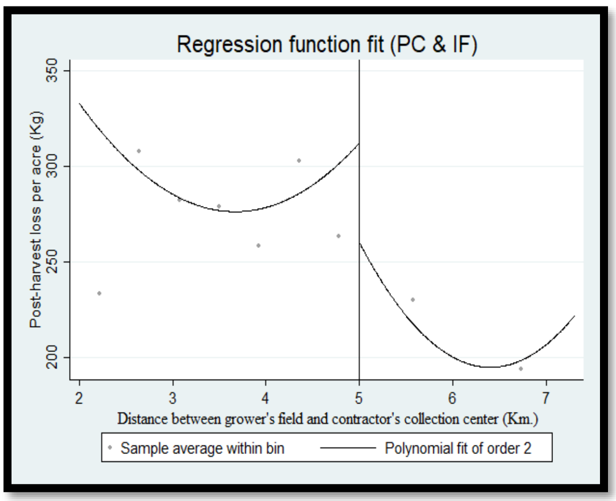




**Figure 7:** Profit per acre between PC and IF

**Figure 8:** Profit per acre between MC and IF



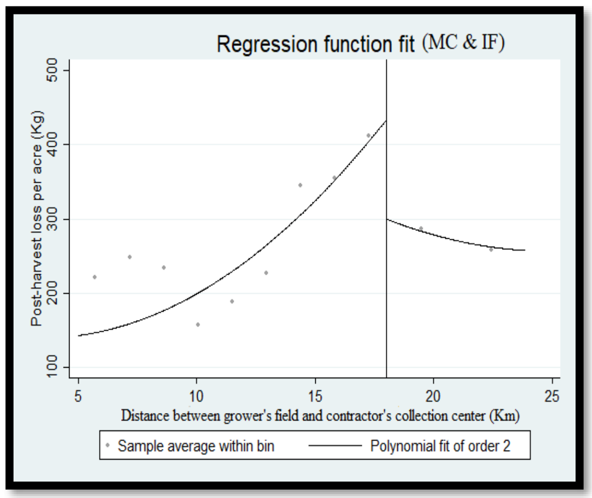
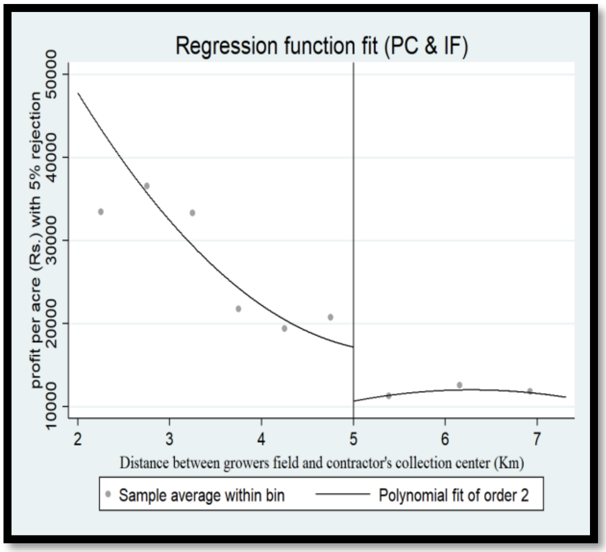




**Figure 9:** Post-harvest losses per acre between PC & IF **Figure 10:** Post-harvest losses per acre between MC & IF



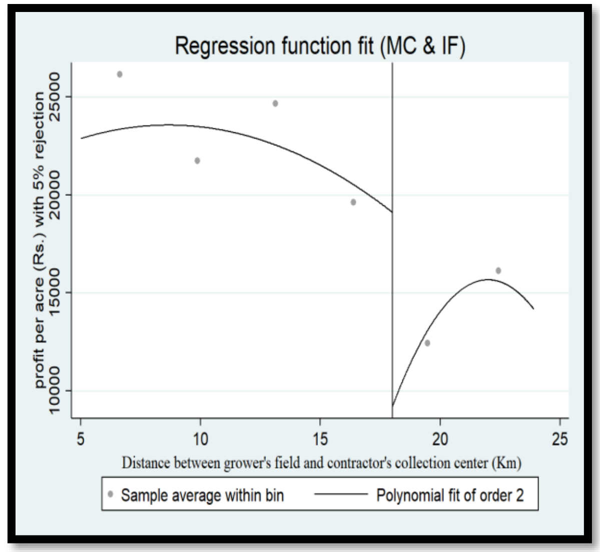
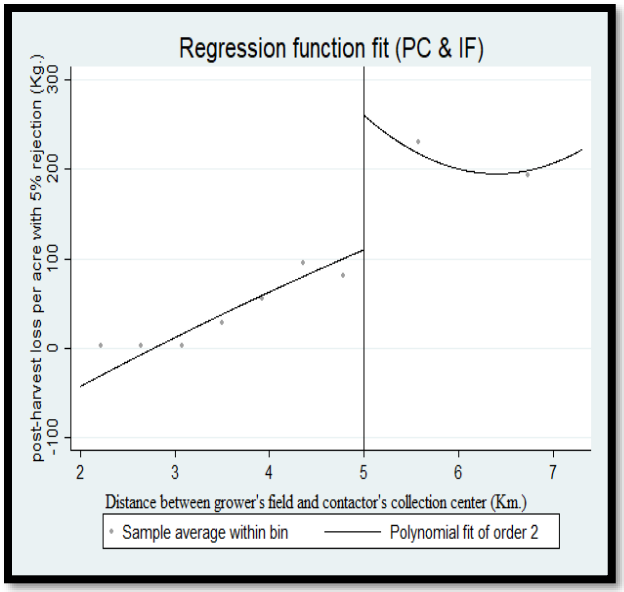




**Figure 12:** Profit per acre with 5% rejection (PC and IF)

**Figure 13:** Profit per acre with 5% rejection (MC and IF)



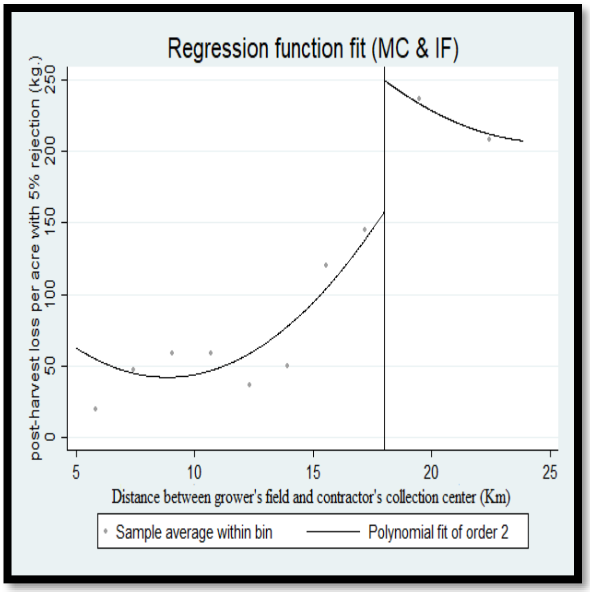




**Figure 14:** Post-harvest per acre with 5% rejection (PC & IF)

**Figure 15:** Post-harvest losses per acre with 5% rejection (MC & IF)

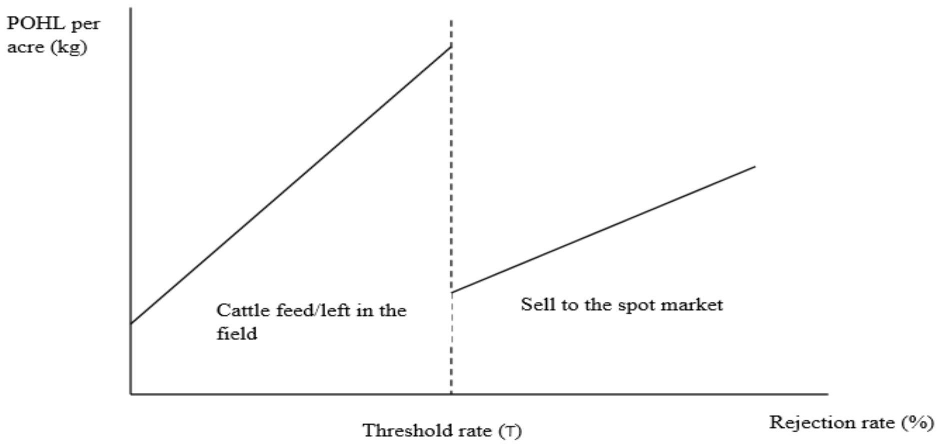



Figure 16: Relationship between PHL per acre and rejection rate (%)

**Table 1:** Variable definition and summary statistics

| | PC and IF Belgaum district | | Difference of means | MC and IF Mysore district | | Difference of means |
|---|---|---|---|---|---|---|
| | *PC growers* | *IF growers* | | *MC growers* | *IF growers* | |
| Covariates | Mean (Std error) | Mean (Std error) | | Mean (Std error) | Mean (Std error) | |
| Age of household head (years) | 44 (0.88) | 43 (1.03) | 0.78 (1.41) | 44 (0.71) | 43.5 (0.91) | 0.58 (0.58) |
| Education (years) | 1.72 (0.03) | 1.65 (0.03) | 0.07* (0.04) | 1.81 (0.08) | 1.48 (0.10) | 0.34 (0.13) |
| General caste (%) | 72 (0.03) | 68 (0.04) | 0.05 (0.05) | 72 (0.03) | 49 (0.05) | 0.23*** (0.05) |
| Experience of HH in farming (years) | 24 (0.93) | 27 (1.08) | -2.28 (1.48) | 24 (0.70) | 25 (0.89) | -1.65 (1.14) |
| Land owned (acres) | 1.63 (0.08) | 1.64 (0.09) | -0.006 (0.13) | 0.80 (0.03) | 1.55 (0.08) | -0.76*** (0.08) |
| No of plots (nos) | 1.73 (0.07) | 1.63 (0.08) | 0.10 (0.12) | 1.24 (0.03) | 1.51 (0.07) | -0.27*** (0.07) |
| Dependency ratio | 0.27 (0.02) | 0.28 (0.03) | -0.01 (0.04) | 0.21 (0.02) | 0.36 (0.03) | -0.14*** (0.04) |
| Water quality (=1 fit for irrigation) | 70 (0.03) | 65 (0.04) | 5 (0.05) | 86 (0.02) | 97 (0.02) | -0.10*** (0.03) |
| Distance to nearest road (Km) | 0.82 (0.4) | 0.84 (0.03) | -0.02 (0.06) | 0.76 (0.03) | 0.75 (0.03) | 0.01 (0.04) |
| Distance of nearest bus station (Km) | 1.13 (0.06) | 1.30 (0.09) | -1.19 (0.05) | 1.26 (0.83) | 1.35 (0.15) | -0.08 (0.16) |
| Distance to irrigation source (Km) | 1.73 (0.17) | 1.82 (0.08) | -0.08 (0.23) | 0.96 (0.18) | 1.30 (0.08) | -0.34 (0.24) |
| Distance to cooperative center (Km) | 1.71 (0.28) | 1.12 (0.09) | 0.59 (0.39) | 2.80 (0.23) | 1.88 (0.39) | 0.93** (0.42) |
| Dependent variables | | | | | | |
| *Profit (Rs./acre)* | 36,903 (1240.63) | 12,069 (410.21) | 24833*** (1681.02) | 20,054 (904.76) | 14,819 (873.67) | 5,235*** (1353.58) |
| *Profit with 5% rejection (Rs./acre)* | 44,273 (1362.17) | 12,069 (410.83) | 32,203*** (1840.41) | 23,537 (978) | 14,819 (873.67) | 8,718*** (1436.92) |
| *PHL (Kg/acre)* | 301 (19.49) | 221 (11.49) | 81*** (27.36) | 315 (15.84) | 284 (10.37) | 31 (22.06) |
| *PHL 5% rejection (Kg/acre)* | 2.14 (0.59) | 221 (9.21) | -219*** (7.13) | 48 (3.47) | 284 (10.37) | -236*** (9.16) |
| *Rejection rate (%)* | 13 (0.47) | 0 | 13*** (0.63) | 11 (0.23) | 0 | 11*** (0.30) |
| No. of observations | 210 | 120 | | 210 | 120 | |
| Effective number of observations | 100 | 86 | | 110 | 80 | |

Note: ns denotes not significant. *,**,*** shows significance at the 10%, 5% and 1%, respectively. Effective number of observations is actually used in the estimation. These are less than the total sample due to the threshold considered for the fuzzy RDD.

**Table 2:** Pre-intervention smoothness of covariates

| | PC and IF (5 km) cut-off | | Difference of means | MC and IF (18 km) cut-off | | Difference of means |
|---|---|---|---|---|---|---|
| | PC growers below cut-off (1 km bandwidth) | IF growers above cut-off (1.2 km bandwidth) | | MC growers below cut-off (1 km bandwidth) | IF growers above cut-off (1.20 km bandwidth) | |
| **Covariates** | Mean (Std error) | Mean (Std error) | | Mean (Std error) | Mean (Std error) | |
| Age, household head (HH) (years) | 44 (0.79) | 43 (1.52) | 1.14 $^{ns}$ (1.98) | 43 (0.95) | 43 (1.65) | -0.39 $^{ns}$ (1.82) |
| Education (years) | 1.70 (0.08) | 1.61 (0.208) | 0.09 $^{ns}$ (0.22) | 1.61 (0.17) | 1.51 (0.18) | 0.09 $^{ns}$ (0.22) |
| General caste (%) | 69 (0.02) | 70 (0.07) | -1 $^{ns}$ (0.04) | 58 (0.05) | 49 (0.08) | -55 $^{ns}$ (0.04) |
| Farming experience of HH (years) | 25 (12.83) | 28 (12.07) | -2.08 $^{ns}$ (2.08) | 23 (0.90) | 25 (1.58) | -2 $^{ns}$ (1.73) |
| Land owned (acres) | 1.62 (0.073) | 1.73 (0.15) | -0.12 $^{ns}$ (0.18) | 1.15 (0.09) | 1.62 (0.15) | -1.28** (0.08) |
| No of plots | 1.71 (0.05) | 1.5 (0.11) | 0.25 $^{ns}$ (0.16) | 1.33 (0.07) | 1.56 (0.15) | -0.23 $^{ns}$ (0.14) |
| Dependency ratio | 0.26 (0.02) | 0.31 (0.04) | -0.29 $^{ns}$ (0.33) | 0.33 (0.03) | 0.41 (0.06) | -0.08 $^{ns}$ (0.06) |
| Water quality (=1 fit for irrigation) | 66 (0.03) | 75 (0.06) | -8 $^{ns}$ (0.07) | 93 (0.03) | 97 (0.02) | 5 $^{ns}$ (0.04) |
| Distance to nearest road (Km) | 0.84 (0.04) | 0.78 (0.04) | -0.83 $^{ns}$ (0.03) | 0.73 (0.4) | 0.74 (0.6) | -0.01 $^{ns}$ (0.08) |
| Distance nearest bus station (Km) | 1.16 (0.05) | 1.34 (0.15) | -0.17 $^{ns}$ (0.14) | 1.42 (0.18) | 1.26 (0.18) | 0.16 $^{ns}$ (0.31) |
| Distance irrigation source (Km) | 1.80 (0.14) | 1.71 (0.15) | 0.11 $^{ns}$ (0.33) | 1.54 (0.35) | 1.23 (0.13) | 0.30 $^{ns}$ (0.55) |
| Distance cooperative center (Km) | 1.62 (0.24) | 1.19 (0.16) | 0.42 $^{ns}$ (0.57) | 3.22 (0.43) | 1.06 (0.13) | 2.16** (0.67) |
| The effective number of observations | 100 | 86 | | 110 | 80 | |

Note: ns denotes not significant; *,**,*** shows significance at the 10%, 5% and 1%, respectively.

**Table 3:** Impact of the distance between grower's field and contractor's collection center on the adoption of PC, profits, and PHL (business as usual)

| Variable | Fuzzy RDD (Cut-off at 5 km) | | | | |
|---|---|---|---|---|---|
| | Adoption of PC | ATE Profit (Rs/acre) | % difference b/w PC and IF | ATE PHL (Kg/acre) | % difference b/w PC and IF |
| Conventional | -4.26** (1.99) | 10,562** (5196) | 87% | 105 (50.38) | 52% |
| **Bias-corrected** | **-4.47** (1.99)** | **12,212** (5196)** | **101%** | **110 (50.38)** | **53%** |

Note: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

**Table 4:** Impact of the distance between grower's field and contractor's collection center on the adoption of MC, profits, and PHL (business as usual)

| Variable | Fuzzy RDD (Cut-off at 18 km) | | | | |
|---|---|---|---|---|---|
| | Adoption of MC | ATE Profit (Rs/acre) | % difference b/w MC and IF | ATE PHL (Kg/acre) | % difference b/w MC and IF |
| Conventional | -1.76*** (0.43) | 5,142* (3042.4) | 34% | 60 (42.6) | 22% |
| **Bias-corrected** | **-1.82*** (0.43)** | **5,964** (3042.4)** | **40%** | **72 (42.6)** | **26%** |

Note: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

**Table 5:** Impact of the distance between grower's field and contractor's collection center on the adoption of PC, profits and PHL (both with 5% rejection)

| Variable | Fuzzy RDD (Cut-off at 5 km) | | | | |
|---|---|---|---|---|---|
| | Adoption of PC | ATE Profit (Rs/acre) | % difference b/w PC and IF | ATE PHL (Kg/acre) | % difference b/w PC and IF |
| Conventional | -4.26** (1.99) | 13,431** (6412) | 111% | -169* (90.32) | -83% |
| **Bias-corrected** | **-4.47** (1.99)** | **14,575** (6412)** | **120%** | **-186** (90.32)** | **-91%** |

Note: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

**Table 6:** Impact of the distance between grower's field and contractor's collection center on the adoption of MC and profits and PHL (both with 5% rejection)

| Variable | Fuzzy RDD (Cut-off at 18 km) | | | | |
|---|---|---|---|---|---|
| | Adoption of PC | ATE Profit (Rs/acre) | % difference b/w MC and IF | ATE PHL (Kg/acre) | % difference b/w MC and IF |
| Conventional | -1.76***<br>(0.43) | 8,609*<br>(4938.5) | 57% | -98**<br>(49.2) | -44% |
| **Bias-corrected** | **-1.82***<br>(0.43)** | **9,680**<br>(4938.5)** | **64%** | **-110**<br>(49.2)** | **-49%** |

Note: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.