IEOM

7th North American International Conference on Industrial Engineering and Operations Management

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June 12-14, 2022

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Industrial Engineering and Operations Management Society International

IEOM Society International, 21411 Civic Center Dr., Suite 205, Southfield, Michigan 48076, USA
Phone: 1-248-450-5660, Email: info@ieomsociety.org

Welcome to the 7th North American Conference on Industrial Engineering and Operations Management in Orlando

To All-Conference Attendees:

On behalf of the IEOM Society International, we would like to welcome you to the 7th North American **International Conference on Industrial Engineering and Operations Management,** June 11-14, 2022, hosted by Florida Polytechnic University. The venue is Holiday Inn & Suites Across from Universal Orlando. This unique international conference provides a forum for academics, researchers, and practitioners from many industries to exchange ideas and share recent developments in the fields of industrial engineering and operations management. This diverse international event provides an opportunity to collaborate and advance the theory and practice of major trends in industrial engineering and operations management. There were more than 600 papers/abstracts submitted from 40 countries. After a thorough peer-review process, more than 450 have been accepted for presentation and publication. The program includes many cutting-edge topics in industrial engineering and operations management.

This conference will address many of the issues concerning the continuous improvement of quality and service. The IEOM Society is delighted to have the following keynote speakers at their 7th North American Conference:

1. Dr. Randy Avent, President, Florida Polytechnic University, Florida, USA
2. Dr. Kay M. Stanney, CEO and Founder, Design Interactive, Inc. and Member, National Academy of Engineering (NAE), Orlando, Florida, USA
3. Professor Alex Frino, Deputy Vice-Chancellor (Global Strategy), University of Wollongong, Wollongong, NSW, Australia
4. Ms. Jessica Ascough, Chief Software Architect, AI Solutions Architect, Data Scientist, L3Harris Technologies, Florida, USA
5. Dr. Regina Relva Romano, Professor and Head of Smart Cities at Facens, Advisor to Brazil's Ministry of Science, Technology, Innovation, and Communication, Brazil
6. H.D. Polumbo Jr., Maj Gen USAF (retired), Founding Partner and Senior Consultant, Two Blue Aces LLC, Winter Haven, Florida, USA
7. Dr. Duane Davis, Chief Physician Executive AdventHealth Institutes, Orlando, Florida, USA
8. Ms. Donna Slyster, Senior Vice President and CIO, Saddle Creek Logistics Services, Florida, United States
9. Dr. Mary Vollaro, Professor and Chair, Department of Mechanical Engineering and Environmental Engineering, Florida Polytechnic University, Lakeland, FL USA
10. Dr. Mansooreh Mollaghasemi, Associate Professor, Industrial Engineering & Management Systems Department, University of Central Florida, Orlando, Florida, USA
11. Dr. Ahmed Kamel, Senior Key Expert, Additive Manufacturing and Innovation, Siemens Energy, Orlando, Florida, United States
12. Dr. Timothy Kotnour, Lockheed Martin St. Laurent Professor, Department of Industrial Engineering and Management Systems, University of Central Florida, Orlando, Florida, USA

At this conference, the IEOM Society will hold its 30th Global Engineering Education session. It will feature distinguished speakers who will discuss workforce readiness and engineering education challenges and opportunities. The 29th IEOM Industry Solutions will showcase will also be held and feature major topics including IoT, AI, data analytics, iCloud, cybersecurity, automation, digital manufacturing, MSV, and industry best practices. The 9th IEOM Global Supply Chain and Logistics will address the global logistic challenges due to the pandemic. Eight-panel sessions have been planned: Industry 4.0, Industry Solutions, Global Engineering Education, Supply Chain, Women in Industry and Academia, Presidential Panel on the Future of IEOM Discipline, and Diversity & Inclusion sponsored by Ford Motor Company.

The IEOM Society would like to express our deep appreciation to our sponsors, university partners, organization partners, exhibitors, authors, reviewers, keynote speakers, panelists, track chairs, advisors, the local committee, and the many volunteers who have given so much of their time and talent to make this unique international conference an overwhelming success.

Our conference host, Florida Polytechnic University, would like to extend a warm welcome to all participants. The IEOM Society Conference Organizing and Planning Committee hopes you enjoy visiting Orlando.

Our very best wishes to all of you for a successful and memorable event.

Dr. Shahram Taj
Chair and Professor, Department of Data Science & Business Analytics, Florida Polytechnic University, USA

Dr. Ahmad Elshennawy
Professor, Department of Industrial Engineering and Management Systems, University of Central Florida, Orlando, FL, USA

Dr. Ahad Ali
Associate Professor and Director of Industrial Eng. Lawrence Tech Univ. MI, USA Executive Director, IEOM Society

Dr. Reinaldo Sanchez-Arias, Assistant Chair Department of Data Science and Business Analytics, Florida Polytechnic University, Florida, USA

Dr. Doga Demirel
Assistant Chair of the Computer Science Department at Florida Polytechnic University, Florida, USA

Conference Overall Program

Day 1 – June 11 (Saturday)

Student Competitions (Virtual) + Parallel Sessions

Day 2 – June 12 (Sunday)

8:00 – 9:30 am – Plenary I, Global Engineering Education and Parallel Sessions

9:30 – 10:00 am – Networking and Coffee Break

10:00 – 10:20 am – Welcome and Opening

10:20 – 11:00 am – Keynote Speaker I: Dr. Randy Avent, President, Florida Polytechnic University, Florida, USA

11:00 – 11:40 am – Keynote Speaker II: Dr. Kay M. Stanney, CEO and Founder, Design Interactive, Inc. and Member, National Academy of Engineering (NAE), Orlando, Florida, USA

11:40 am – 12:20 pm – Keynote Speaker III: Professor Alex Frino, Deputy Vice-Chancellor (Global Strategy), University of Wollongong, Wollongong, NSW, Australia

12:20 – 1:00 pm – Keynote Speaker IV: Ms. Jessica Ascough, Chief Software Architect, AI Solutions Architect, Data Scientist, L3Harris Technologies, Florida, USA

1:00 – 2:00 pm Networking Lunch (Provided)

2:00 – 3:30 pm – Panel I, Global Engineering Education and Technical Parallel Sessions

3:30 – 4:00 pm – Networking and Coffee Break

4:00 – 6:00 pm – Panel II – Presidential Panel on the Future of IEOM Discipline

Day 3 – June 13 (Monday)

8:00 – 9:30 am – Industry Solutions and Technical Parallel Sessions

9:30 – 10:00 am – Networking and Coffee Break

10:00 – 10:20 am – Conference Chair Remarks

10:20 -11:00 am – Keynote Speaker V: Dr. Regiane Relva Romano, Professor and Head of Smart Cities at Facens, Advisor to Brazil's Ministry of Science, Technology, Innovation and Communication, Brazil

11:00 – 11:40 am – Keynote Speaker VI: H.D. Polumbo Jr., Maj Gen USAF (retired), Founding Partner and Senior Consultant, Two Blue Aces LLC, Winter Haven, Florida, USA

11:40 am – 12:20 pm – Keynote Speaker VII: Dr. Duane Davis, Chief Physician Executive AdventHealth Institutes, Orlando, Florida, USA

12:20 – 1:00 pm – Keynote Speaker VIII: Ms. Donna Slyster, Senior Vice President and CIO, Saddle Creek Logistics Services, Florida, USA

1:00 – 2:00 pm – Networking Lunch (Provided)

2:00 – 3:30 pm – Panel III, Industry Solutions and Technical Parallel Sessions

3:30 – 4:00 Networking and Coffee Break

4:00 – 6:00 pm – Panel IV, Industry Solutions and Technical Parallel Sessions

Day 4 – June 14 (Tuesday)

8:00 – 9:30 am – Global Supply Chain & Logistics and Parallel Sessions

9:30 – 10:00 am – Networking and Coffee Break

10:00 – 10:20 am – Conference Industry Chair Remarks

10:20 -11:00 am – Keynote Speaker IX: Dr. Mary Vollaro, Professor and Chair, Department of Mechanical Engineering and Environmental Engineering, Florida Polytechnic University, Lakeland, FL USA

11:00 – 11:40 am – Keynote Speaker X: Dr. Mansooreh Mollaghasemi, Associate Professor, Industrial Engineering & Management Systems Department, University of Central Florida, Orlando, Florida, USA

11:40 am – 12:20 pm – Keynote Speaker XI: Dr. Ahmed Kamel, Senior Key Expert, Additive Manufacturing and Innovation, Siemens Energy, Orlando, Florida, United States

12:20 – 1:00 pm – Keynote Speaker XII: Dr. Timothy Kotnour, Lockheed Martin St. Laurent Professor, Department of Industrial Engineering and Management Systems, University of Central Florida, Orlando, Florida, USA

1:00 – 2:00 pm – Networking Lunch (Provided)

2:00 – 3:30 pm – Panel V, Global Supply Chain & Logistics and Parallel Sessions

3:30 – 4:00 pm – Networking and Coffee Break

4:00 – 6:00 pm – Panel VI, Global Supply Chain & Logistics and Parallel Sessions

7:00 – 10:00 pm – Conference Awards Dinner (Student registraton does not include dinner, student can buy dinner ticket)

Keynote Speakers – Ballroom (Room 1)

Conference Welcome and Opening: Sunday, June 12, 2022, 10:00 – 10:20 am

Opening Keynote I: Sunday, June 12, 2022, 10:20 – 11:00 am

Dr. Randy Avent

President
Florida Polytechnic University
Florida, USA

Dr. Randy K. Avent is founding president of Florida Polytechnic University, the state's only public university dedicated 100% to STEM. Named the University's inaugural president in 2014, Avent is responsible for its development and operation, and is committed to strategically advancing Florida Poly as a research-and-jobs institution, an agent for growth, and a beacon for the economy. His career exemplifies the qualities of innovation, leadership, and entrepreneurship the University seeks to instill in students. An accomplished academician, senior administrator, and research scientist, Avent has an extensive background teaching and directing research at higher-education institutions dedicated to science, technology, engineering, and mathematics (STEM).

Keynote II: Sunday, June 12, 2022, 11:00 – 11:40 am

Kay M. Stanney, Ph.D.

CEO and Founder, Design Interactive, Inc.
Member, National Academy of Engineering (NAE)
Orlando, Florida, USA

Dr. Kay M. Stanney is CEO and Founder of Design Interactive (DI), Inc., a woman-owned, small business focused on human-systems integration. She is recognized as a leader in eXtended Reality (XR, Virtual Reality, Augmented Reality, Mixed Reality) systems, especially as they relate to training, human performance, and cybersickness. In 2019, she was inducted into the National Academy of Engineering (NAE) for her contributions to human factors engineering through virtual reality technology and strategic leadership. Her research has influenced the design of current generation XR headsets, Universal Studios and Disney immersive experiences, Chevron immersive environments, Procter & Gamble training solutions, as well as numerous military XR systems. Stanney has been a pioneer in formalizing XR R&D by serving as editor of the Handbook of Virtual Environments: Design, Implementation, and Applications (1st edition, 2002, LEA; 2nd edition, 2014, CRC Press), cofounding/ co-chairing the 1st International Conference on Virtual Reality, and co-founding the Virtual Environments Technical Group (VETG) within the Human Factors and Ergonomics Society. In recognition of these efforts, Dr. Stanney received the 2006 IEEE Virtual Reality Technical Achievement Award from the IEEE Computer Society, an award designed to honor individuals for their seminal technical achievement in virtual and augmented reality.

Keynote III: Sunday, June 12, 2022, 11:40 am – 12:20 pm

Professor Alex Frino

Deputy Vice-Chancellor (Global Strategy)
University of Wollongong
Wollongong, NSW, Australia

Professor Alex Frino is a distinguished financial economist who fosters the interaction of business with academe. He is an alumnus of UOW and Cambridge University, and a former Fulbright Scholar. He is one of the best published financial economists in the world with over 100 papers in leading scholarly journals. He has won over $10 million in competitive research funding and is frequently cited in the global press. Professor Frino was previously Chief Executive Officer of the Capital Markets Cooperative Research Centre Ltd and has held visiting academic positions at leading Universities in Italy, New Zealand, the UK and the United States. He has also held positions with leading financial market organisations, including the Sydney Futures Exchange, Credit Suisse and the Commodity Futures Trading Commission in the USA. He is regularly called upon to act as an independent expert witness in major Australian court cases and has acted as a consultant to many large Australian listed companies.

Keynote IV: Sunday, June 12, 2022, 12:20 – 1:00 pm

Ms. Jessica Ascough

Chief Software Architect, AI Solutions Architect, Data Scientist
L3Harris Technologies
Florida, USA

Jessica Ascough is a L3Harris Technologies Scientist. Over the past twenty-eight years Jessica has served as a Chief Software Engineer, Chief Software Architect, Principal Investigator, Solutions Architect, and Data Scientist, identifying and developing software, system, security, mission critical network, energy, predictive analytics, algorithmic processing chain, and artificial intelligence solutions and services for proprietary and commercial programs. Jessica has five U.S. patents for Seismic Analysis and one patent pending for Patterns-of-Life/Patterns-of-Activity Normalcy Models. Jessica's L3Harris awards include "Trusted Advisor & Industry Thought Leader", "Innovation", "Rainmaker", "Beyond the Call of Duty", "Outstanding Leadership", "Teamwork", "Golden Quill", and "Best Conference Paper". Jessica has actively participated in, and presented at, organizations and conferences such as the North American SynchroPhasor Initiative (NASPI).

Jessica was the 2010 Co-Chair of the Cybersecurity Working Group for the international Network Centric Operations Industry Consortium (NCOIC). Currently, Jessica is performing Chief Systems Engineer duties for an analytics hybrid cloud App Store Marketplace. Recently, Jessica architected an unsupervised real-time dissimilar phenomenologies generalized upstream fusion framework, that is mission and data independent, to generate generic normalcy models.

Previously, Jessica worked ten years with Florida Power Corporation, now Duke Energy, and was the first female Journeyman Lineman, constructing, maintaining, and troubleshooting electrical power distribution and transmission lines. Jessica holds a Bachelor's of Science in Computer Science (BSCS) from USF, a Master's of Science in Engineering Management (MSEM) from UCF, and a Master's of Science in Predictive Analytics (MSPA) from Northwestern University.

Monday, June 13, 2022

Conference Chair Remarks: Monday, June 13, 2022, 10:00 – 10:40 am

Keynote V: Monday, June 13, 2022, 10:20 – 11:00 am

Dr. Regiane Relva Romano
Professor and Head of Smart Cities at Facens
Advisor to Brazil's Ministry of Science, Technology, Innovation and Communication, Brazil

Has over 30 years of international experience working in technology and innovation. Former as Special Adviser to the Ministry of Science, Technology and Innovation in Brazil. Head of Research and General Coordinator at Smart Campus FACENS, a prototype of a Smart City inside the College, that received the "Top Educational/ABMES" and the "Innovation GS1" awards in 2016; "Smart City UK-London" in 2017; "Best IoT Implementation Europe IdTechEx"; "Top of Academy/RFIDBR/2018" and "InovaCidade" at Smart City Business America 2019. Also work as CEO at VIP-SYSTEMS Informática. Writer. Professor at FGV, FIA, ESALQ/USP, FDC, EINSTEIN and FACENS. International speaker. Consultant of innovation and technologies applied to businesses, retail and Smart Cities. As a researcher in the business and emerging technologies, she has lectured in China, Dubai, Germany, Colombia, Poland, The Netherlands, Uruguay, Canada, Spain, Perú, Portugal, United States, and others. She developed the First Smart Store in Latin America, in 2011, and is widely recognized as an expert in topics related to Smart and Sustainable Cities, retail, RFID and technology. She earned a Ph.D. in a concentration in Information Technology Management, at FGV and a Master's degree in Informatics Management of Information Systems from PUC-CAMPINAS. She completed some studies in the improvement of international Retailing at the University of Ohio, in RFID at the University of Arkansas, in Business at Columbia University and in Smart Cities at Lleida University.

Keynote VI: Monday, June 13, 2022, 11:00 – 11:40 am

H.D. Polumbo Jr.
Maj Gen USAF (retired)
Founding Partner and Senior Consultant
Two Blue Aces LLC, Winter Haven, Florida, USA

Major General H.D. "Jake" Polumbo (ret) is a founding partner and senior consultant for Two Blue Aces, LLC, a leadership firm that specializes in strategic reviews, business plan development, leadership training and mentoring. His primary focus is in the defense and aerospace sectors, with an emphasis on leadership and business networking. In 2015, after 34 years of service, Jake retired from the Air Force as the commander of the Ninth Air Force in South Carolina, comprising eight active-duty wings in the southeastern United States with more than 450 aircraft and over 29,000 active-duty and civilian personnel.

He entered active duty as a graduate of the U.S. Air Force Academy in 1981 and commanded at the squadron, group, and three times at the wing level. He served in strategic planning positions in Europe as the director of strategy and plans at U.S. Africa Command and in the Pentagon as the assistant deputy director for Global Operations on the Joint Staff. General Polumbo also served as a task force commander in Afghanistan in 2012. He attended the Federal Executive Institute and was a Senior Fellow at Georgetown University's Institute for the Study of Diplomacy. A decorated command pilot, Jake logged over three thousand flying hours in all models of the F-16 and holds the distinction as the first and only U.S. Air Force general officer to fly the U-2S in combat, completing twenty-one missions in Operations Enduring Freedom and Iraqi Freedom.

Jake is the Past Chair on the Board of the Central Florida Development Council, serves as an advisor for the aviation program at Southeastern University in Lakeland, Florida, and also volunteers for his church in various capacities. He is active in the local General Aviation community, is a Certified Flight Instructor – Instrument (CFII) in single and multi-engine land aircraft as well as an instructor pilot in single engine seaplanes. Jake and his wife Sandra, a Florida native, have been married for forty years. Their oldest son, Chad, is a Lieutenant Colonel in the U.S. Air Force with his wife, Julie, and they have two sons, Nolan and Garrett. Jake and Sandra's youngest son, Erik, lives in Virginia with his wife, Alexine, where they run four very successful businesses together.

Keynote VII: Monday, June 13, 2022, 11:40 am – 12:20 pm

Dr. Duane Davis
Chief Physician Executive
AdventHealth Institutes
Orlando, Florida, USA

Dr. Duane Davis is the Chief Physician Executive of AdventHealth Institutes. As CPE, Dr. Davis oversees the Cardiovascular, Cancer, Neurosciences, Orthopedic, Digestive Diseases and Surgery Institutes of AdventHealth Central Florida Division based in Orlando, Florida. He is responsible for strategy, quality and consultative engagement for the finances and operations of these Institutes, all nationally ranked or recognized by U.S. News & World Report. He remains clinically active in the lung transplant and CTEPH programs.

Prior to joining AdventHealth, Dr. Davis was Professor of Surgery and Director of Transplantation at Duke University Medical Center, where he served for over two decades. Prior to leaving Duke, he had performed the most lung transplants worldwide. Published in more than 250 referred journals, Dr. Davis has also contributed to 27 books and over 150 selected abstracts. As an expert in his field, Dr. Davis has been served as a consultant on over 58 advisory boards and committees and has given numerous educational presentations worldwide. His areas of research interest include: the role of environmental exposure and innate immunity of chronic pulmonary allograft injury; optimization of donor lung utilization—novel strategies to preserve and improve lung organ function; lung transplant outcomes; and tolerance in lung transplantation. Since 2010, his research has raised NIH external support exceeding $4 million. He is currently licensed to practice medicine in Florida, North Carolina, Missouri and Virginia, and certified by the National Board of Medical Examiners, the American Board of Surgery, and the American Board of Thoracic Surgery. Dr. Davis received his Doctor of Medicine from the University of California medical school in Los Angeles, California, and later earned a Master of Business Administration from Fuqua School of Business at Duke University, focused on Health Sector Management. He holds two Bachelor of Science degrees from Stanford University in Chemical Engineering and Biologic Sciences. He is married with three children and resides in Winter Park, Florida.

Keynote VIII: Monday, June 13, 2022, 12:20 – 1:00 pm

Ms. Donna Slyster
Senior Vice President and CIO
Saddle Creek Logistics Services
Florida, United States

Quality-driven Global Supply Chain and Information Technology Executive who delivers consistent successful results for increased shareholder value, business profitability, customer satisfaction and employee engagement. Exceptional in building global teams and creating business partnerships that drive improved performance and innovation. Extensive experience in developing Supply Chain solutions, process improvements, system implementations and people leadership. Skilled in the following competencies: Executive Leadership, Strategic Planning, Change Management, Operations Leadership, Vendor Relationships, Project Management, Systems Implementation, Financial Management and Six Sigma Solutions.

Tuesday, June 14, 2022

Conference Industry Chair Remarks: Tuesday, June 14, 2022, 10:00 – 10:20 am

Keynote IX: Tuesday, June 14, 2022, 10:20 – 11:00 am

Dr. Mary Vollaro
Professor and Chair
Department of Mechanical Engineering and Environmental Engineering
Florida Polytechnic University
Lakeland, FL USA

Dr. Mary B. Vollaro is chair of the Department of Mechanical Engineering and an associate professor of mechanical engineering at Florida Polytechnic University. Prior to that, she was assistant, then associate professor of mechanical engineering from 1997 to 2016 at Western New England University (WNE) in Springfield, Massachusetts. While there she was involved in university governance and chaired the Faculty Senate (twice) and the General University Requirements Committee and the Academic Standards Committee multiple times. She developed the Honors Program in the College of Engineering, as well as the Grand Challenge Scholars Program at WNE.

Vollaro has held engineering positions in industry and holds one patent. Involved with engineering education, she was chair of the ASEE Materials Division and continues to be active in that ASEE Division. She has written in the area of materials science education and is now working on leadership and teaming activities for engineers.

Keynote X: Tuesday, June 14, 2022, 11:00 – 11:40 am

Dr. Mansooreh Mollaghasemi
Associate Professor
Industrial Engineering & Management Systems Department
University of Central Florida
Orlando, Florida, USA

MANSOOREH MOLLAGHASEMI is an associate professor of Industrial Engineering and Management Systems at the University of Central Florida. She received her Ph.D. in Industrial Engineering from the University of Louisville in 1991. She also holds a B.S. and an M.S. in Chemical Engineering from the same University. Her research interests involve simulation modeling and analysis, multiple response simulation optimization, and neural networks. She is a member of IIE and INFORMS.

Keynote XI: Tuesday, June 14, 2022, 11:40 am – 12:20 pm

Dr. Ahmed Kamel
Senior Key Expert, Additive Manufacturing and Innovation
Siemens Energy
Orlando, Florida, United States

Dr. Kamel has more than 25 years in the automotive and gas turbine industries with a focus on rapid prototyping and rapid manufacturing. He is currently a senior key expert of additive manufacturing and innovation at Siemens Energy. In his current role, Dr. Kamel consults for global teams to diffuse the use of additive manufacturing to drive innovation in design, manufacturing and repair of gas turbine components. His research is currently focused on the design of superalloys for 3D printing. Dr. Kamel has been granted more than 100 patents in the US, Europe and Asia. In 2021, he was nominated for the Siemens Energy Inventor of the year award.

He earned his Bachelor of Science and Advanced graduate degrees in Mechanical and Aerospace engineering from the American University in Cairo (Egypt) and Carleton University (Ottawa, Canada). He also holds a doctorate in Business Administration with a focus on Operations management and Innovation from the Crummer Graduate School of Business (Rollins College, Florida). He is also a certified Innovation Engineering practitioner by the Innovation Engineering Institute (Cincinnati, Ohio).

Keynote XII: Tuesday, June 14, 2022, 12:20 – 1:00 pm

Dr. Timothy Kotnour
Lockheed Martin St. Laurent Professor
Department of Industrial Engineering and Management Systems
University of Central Florida
Orlando, Florida, USA

Tim Kotnour, Ph.D., is the Lockheed Martin St. Laurent Professor in the Department of Industrial Engineering and Management Systems at the University of Central Florida. He is the Director of the UCF Engineering Leadership and Innovation Institute (eli2) and the Professional Engineering Management Program. He completed his doctorate in Industrial & Systems Engineering from Virginia Tech. His core work focuses on "making strategy real." He integrates both corporate and academic settings by partnering with senior management teams to develop solutions through technical assistance, education, training, and research. He focuses on strategic management, organizational transformations, and solution delivery. He provides professional presentations and strategic conversation facilitation to leadership teams as large as 200+ people. He has been actively engaged with multiple executive teams in leading significant transformations including NASA's Kennedy Space Center, NASA's Launch Services Program, NASA's Exploration Ground Systems, and the transformation of the packaged-goods model to a mobile, social, and direct-to-consumer business model within the video-game industry. In 2016, 2005, and 2001, Tim was awarded a NASA Public Service Medal for the partnership work with KSC. He has lead transformations within the university setting. He is author of the book "Transforming Organizations: Strategies and Methods" and co-author of the book "Inspiring the Leader Engineer—Instilling the Burning Desire and Confidence to Change the World." He served as the Editor of the Engineering Management Journal and is a Fellow of the American Society for Engineering Management.

The Roles of Steel Industries in the National Economy: The Case of Japan

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Abstract

The purpose of this study is to analyze the roles of steel industries in the national economy of Japan. This study employs Input-Output (IO) analysis as an analysis apparatus. More specifically, this study uses the parts of IO analysis, namely simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis instruments. The analysis period of this study is from 1985 through 2005. In this study, the analyzed sectors are (1) pig iron and crude steel, (2) steel products, and (3) steel castings and forgings, and other steel products. The results show that, by using simple output multiplier, one can say that one of the analyzed industries, steel products, attracted consistently the Japanese economy on the analysis period. The same attractiveness could be observed on pig iron and crude steel sector from 1985 through 1995. Meanwhile, by using both indices, one can claim that the analyzed industrial sectors had a consistent pattern regarding the quadrant location on the period of analysis. More specifically, pig iron and crude steel, and steel products sectors were in quadrant I from 1985 through 2005 while steel castings and forgings, and other steel products sector lied in quadrant IV on the same period. Based on these quadrant positions, one can say that the analyzed industries had strong effects on the entire Japanese industries on the analysis period.

Keywords
Steel Industries, National Economy, IO Analysis, Effects.

1. Introduction

The industrial sectors are important parts of a country. Their contributions can be seen on the micro and macro aspects of a national economy. Also, their important roles can be observed both in developed and developing countries. One of the industrial sectors that worth to be discussed in this matter is the steel industry.

There are many previous studies discuss the steel topic. For example, Al-Karawi (2022) examines the enhancement in local residual stresses and hardness in S355 welded structural steel by means of two post-weld treatment approaches, namely High-Frequency Mechanical Impact (HFMI) treatment and Tungsten Inert Gas (TIG) remelting. Latour et al. (2022) explain an experimental analysis to measure the mechanical properties of aluminium foams and describe Steel-

Aluminium Foam-Steel (SAS) sandwich panels in bending. Ahmed and Tsavdaridis (2019) review some historic and current expansions of Steel-Concrete Composite (SCC) systems, with emphasis on the evolution of lightweight and prefabricated systems as they have attracted significant consideration the last years.

Meanwhile, Ghafouri et al. (2022) develop a computational method based on the Finite Element (FE) approach to efficiently forecast welding deformations and residual stresses of fillet welded T-joints made of High Strength Steel (HSS), S700, applying different welding orders and external constraints. Tran et al. (2022) suggests an efficient process for the reliability analysis of frames with Concrete-Filled Steel Tubular (CFST) columns and composite beams. Tumbeva et al. (2022) present a numerical inquiry of the redundancy of steel truss bridges composed of original modular joints when subjected to the abrupt loss of diagonal components.

On the other hand, Inamasu and Lignos (2022) explores, by means of Continuum Finite Element (CFE) analysis, a newly developed idea that promotes controlled inelastic energy improvidence within the embedded portion of column base connections rather than in steel columns of traditional embedded column bases. Arrayago and Rasmussen (2022) analyze the effect of the way of initial imperfections modelled as linear superpositions of buckling modes on the counteraction of steel and stainless steel frames designed applying advanced analysis. The purpose of their study is to simplify the definition of initial imperfections in design.

Based on the aforesaid previous studies, one can argue that the study to analyze the economic aspect of the steel industry in a specific country is still needed. This study is done to fill the gap. One of the methods in conducting the analysis is Input-Output (IO) analysis, the approach in examining the linkages of industrial sectors in one or more nations. The importance and originality of this study are that it explores the roles of the steel industry by using several calculation procedures from IO analysis which focusing on the national economy of Japan.

The purpose of this study is to analyze the roles of steel industries in the Japanese national economy. This study employs IO analysis as an analysis apparatus. More specifically, this study uses the parts of IO analysis, namely simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis instruments. The analysis period of this study is from 1985 through 2005.

The rest of this paper is elucidated as follows. Section 2 describes the methodology of this study. Section 3 clarifies the results of calculations. The discussions for the results can be observed on this section too. The next section, section 4, defines the conclusions of this study and proposed further studies.

2. Methodology

The methodology of this study is clarified as follows. The first step is to express the data used. This study employs Japanese IO tables for 1985, 1990, 1995, 2000, and 2005 as data. Initially, the tables consist of 84, 91, 93, 104, and 108 industries, respectively. After accomplishing the adjustment process, the tables have 78 industrial sectors. Those industrial sectors are presented in Appendix. The second step is to show the Japanese steel industries used in this study. Table 1 clarifies those industries.

Table 1. Japanese Steel Industries Used in This Study

Sector Number	Sector Name
35	Pig iron and crude steel
36	Steel products
37	Steel castings and forgings, and other steel products

The third step is to perform the calculations by employing simple output multiplier and simple household income multiplier. Miller and Blair (2009) clarify the equations of both multipliers as follows:

$$m(o)_j = \sum_{i=1}^{n} l_{ij} \quad (1)$$

$$m(h)_j = \sum_{i=1}^{n} a_{n+1}\, l_{ij}. \quad (2)$$

The former model describes the simple output multiplier while the latter one clarifies the simple household income multiplier. More specifically, $m(o)_j$, $m(h)_j$, $a_{n+1,i}$, n, and l_{ij} are simple output multiplier for sector j, simple household income multiplier for sector j, the coefficients of labor-input, the number of analyzed industries, and a sector-to-sector multipliers matrix, respectively.

The next step is to conduct the calculations in order to analyze the characteristics of Japanese industries on the period of analysis, especially the Japanese steel industries. The methods applied in the calculations are index of the power of dispersion and index of the sensitivity of dispersion. The former index is employed to analyze the strength of one specific industry in impacting entire industries. A larger impact is aligned with the higher index value. The detail of the index is elucidated by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

$$\text{Index of the power of dispersion by sector} = \frac{b_{*j}}{\bar{B}}. \qquad (3)$$

The numerator is each sum of column in the table of inverse matrix coefficients while the denominator clarifies the mean value of the entire vertical sum in the table of inverse matrix coefficients. More specifically, the equations of numerator and denominator are elucidated as follows:

$$b_{*j} = \sum_i^n b_{ij} \qquad (4)$$

$$\bar{B} = \frac{1}{n}\sum_j b_{*j} = \frac{1}{n}\sum_i \sum_j b_{ij}. \qquad (5)$$

Further, b_{ij} and n are the value of Leontief inverse from sector i to sector j and total number of analyzed industries, respectively. The latter index is employed to investigate the sensitivity of the particular industry to the external effects. A bigger sensitivity is aligned with the higher index value. More specifically, one specific industrial sector is called more sensitive to the effects from the external aspects if it has a larger index value. The detail of the index is clarified by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

$$\text{Index of the sensitivity of dispersion by sector} = \frac{b_{i*}}{\bar{B}}. \qquad (6)$$

In this index, the numerator is each sum of row in the table of inverse matrix coefficients while the denominator explains the mean value of the entire horizontal sum in the table of inverse matrix coefficients. Further, the equations of the numerator and denominator of the index are elucidated as follows:

$$b_{i*} = \sum_j^n b_{ij} \qquad (7)$$

$$\bar{B} = \frac{1}{n}\sum_i b_{i*} = \frac{1}{n}\sum_i \sum_j b_{ij}. \qquad (8)$$

In order to get a compatibility sense with the previous index, equation (7) is slightly transformed from the original source. More specifically, the part states the total number of discussed industries, n, is added into the equation. As with the previous explanation, b_{ij} is the Leontief inverse value from sector i to sector j. Conclusions of the study and suggested further researches are clarified on the last step.

3. Results and Analysis

Tables 2, 3, 4, 5, and 6 display the top five Japanese industrial sectors viewed from the value of simple output multiplier in 1985, 1990, 1995, 2000, and 2005, respectively. Miller and Blair (2009) clarify that an output multiplier for sector j is the total value of production in all industrial sectors of the economy that is needed in order to accomplish a currency's worth of final demand for the output of sector j. They also elucidate that, for the simple output multiplier, the entire value of production is coming from the households exogenous model.

Table 2. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1985 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	36	Steel products	3.456
2	65	Self-transport by private cars	3.283
3	23	Synthetic resins	3.266
4	22	Chemical basic and intermediate products	3.197
5	35	Pig iron and crude steel	3.183

Table 3. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1990 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.104
2	36	Steel products	3.097
3	65	Self-transport by private cars	2.852
4	35	Pig iron and crude steel	2.850
5	23	Synthetic resins	2.805

Table 4. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1995 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.063
2	36	Steel products	2.887
3	65	Self-transport by private cars	2.748
4	11	Feeds and organic fertilizer, n.e.c.	2.717
5	35	Pig iron and crude steel	2.672

Table 5. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 2000 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.112
2	36	Steel products	2.967
3	23	Synthetic resins	2.916
4	22	Chemical basic and intermediate products	2.882
5	65	Self-transport by private cars	2.820

Table 6. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 2005 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.449
2	23	Synthetic resins	3.302
3	22	Chemical basic and intermediate products	3.296
4	36	Steel products	3.237
5	65	Self-transport by private cars	2.952

Interestingly, one of the analyzed industries, steel products, can be seen in the tables. This fact clarifies the consistency of the industry in attracting the Japanese economy from 1985 through 2005. The value of the industry in 2005 was 3.237. This result explains that in order to satisfy a yen's worth of final demand for the industry's output in 2005, all Japanese industries needed to produce the products which the total value was ¥3.237. The other analyzed industrial sector that appears in above tables is pig iron and crude steel. The industrial sector can be observed in tables 2, 3, and 4.

Figures 1, 2, and 3 display the simple output multiplier values of analyzed industries on the analysis period. One can argue that those industrial sectors have a same pattern based on the figures. More specifically, the analyzed industries had the increasing-decreasing-increasing pattern from 1985 through 2005.

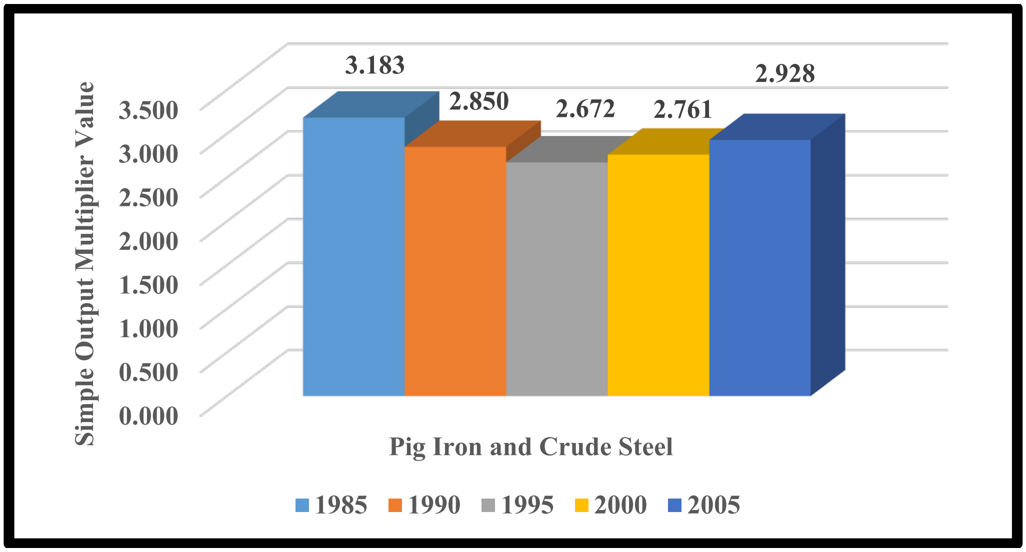

Figure 1. The Simple Output Multiplier Values of the Pig Iron and Crude Steel Sector, 1985-2005

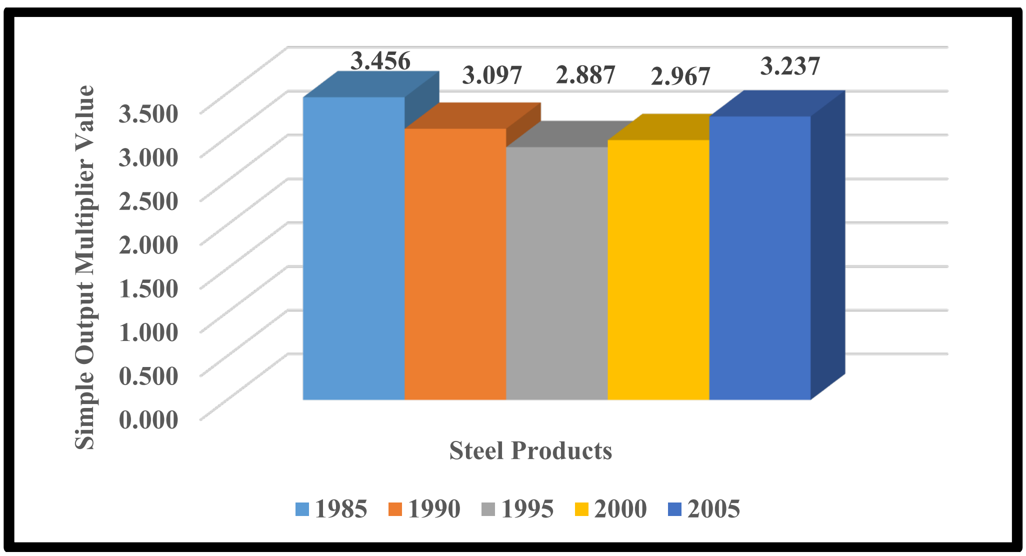

Figure 2. The Simple Output Multiplier Values of the Steel Products Sector, 1985-2005

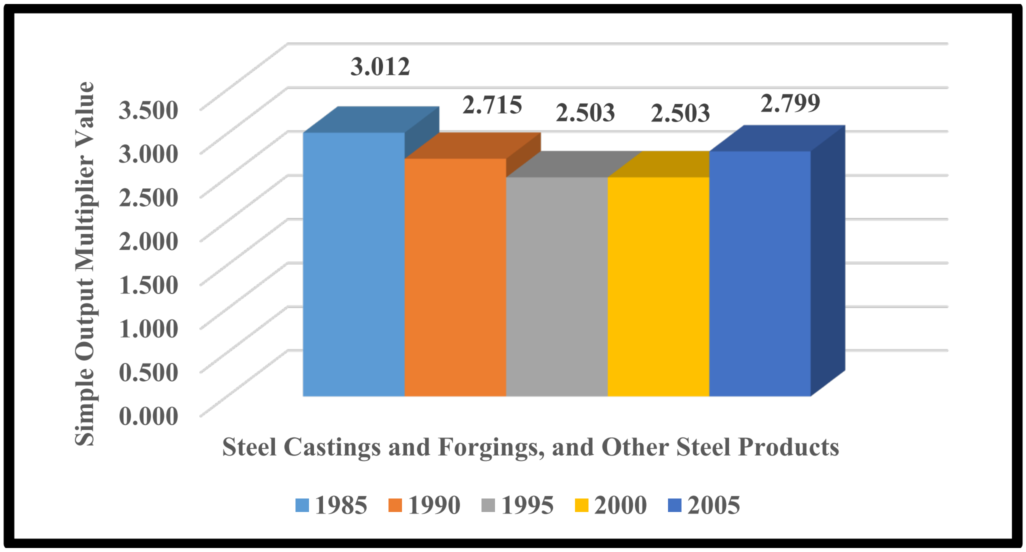

Figure 3. The Simple Output Multiplier Values of the Steel Castings and Forgings, and Other Steel Products Sector, 1985-2005

Tables 7, 8, 9, 10, and 11 explain the top five Japanese industrial sectors viewed from the values of simple household income multiplier in 1985, 1990, 1995, 2000, and 2005, respectively. Miller and Blair (2009) describe that the multiplier is applied to elucidate the economic impacts of new final demand as measured by new households income by using the households exogenous model. The configurations of the tables are different with the ones of the tables of the previous multiplier.

Table 7. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1985 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	63	Railway	0.848
2	73	Education	0.836
3	64	Road transport (except transport by private cars)	0.736
4	58	Waste management service	0.719
5	72	Public administration and activities not elsewhere classified	0.691

Table 8. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1990 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.833
2	58	Waste management service	0.739
3	64	Road transport (except transport by private cars)	0.720
4	72	Public administration and activities not elsewhere classified	0.719
5	76	Other public services	0.709

Table 9. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1995 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.838
2	72	Public administration and activities not elsewhere classified	0.723
3	76	Other public services	0.721
4	64	Road transport (except transport by private cars)	0.720
5	74	Research	0.706

Table 10. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 2000 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.795
2	74	Research	0.715
3	76	Other public services	0.712
4	64	Road transport (except transport by private cars)	0.709
5	75	Medical service, health and social security	0.688

Table 11. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 2005 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.780
2	76	Other public services	0.716
3	64	Road transport (except transport by private cars)	0.684
4	75	Medical service, health and social security	0.676
5	74	Research	0.658

Analyzed steel industries do not include in the tables. By using this result, one can argue that the industries did not make the attractive impact to the economy of Japan on the analysis period from point of view of new household income. One of the interesting points from the second multiplier is two industries include in the tables, namely road transport (except transport by private cars) and education. In 1995, the values of those industries were 0.720 and 0.838, respectively. These values show that, in 1995, an additional yen of final demand for the industries would generate ¥0.720 and ¥0.838 of new household incomes, respectively, when all direct and indirect impacts were transformed into yen estimates of incomes.

Figures 4, 5, and 6 clarify the simple household income multiplier values of analyzed industries on the analysis period. Generally, those industrial sectors have a same pattern based on the figures. More specifically, the analyzed industries had the decreasing-increasing-decreasing movement from 1985 through 2005.

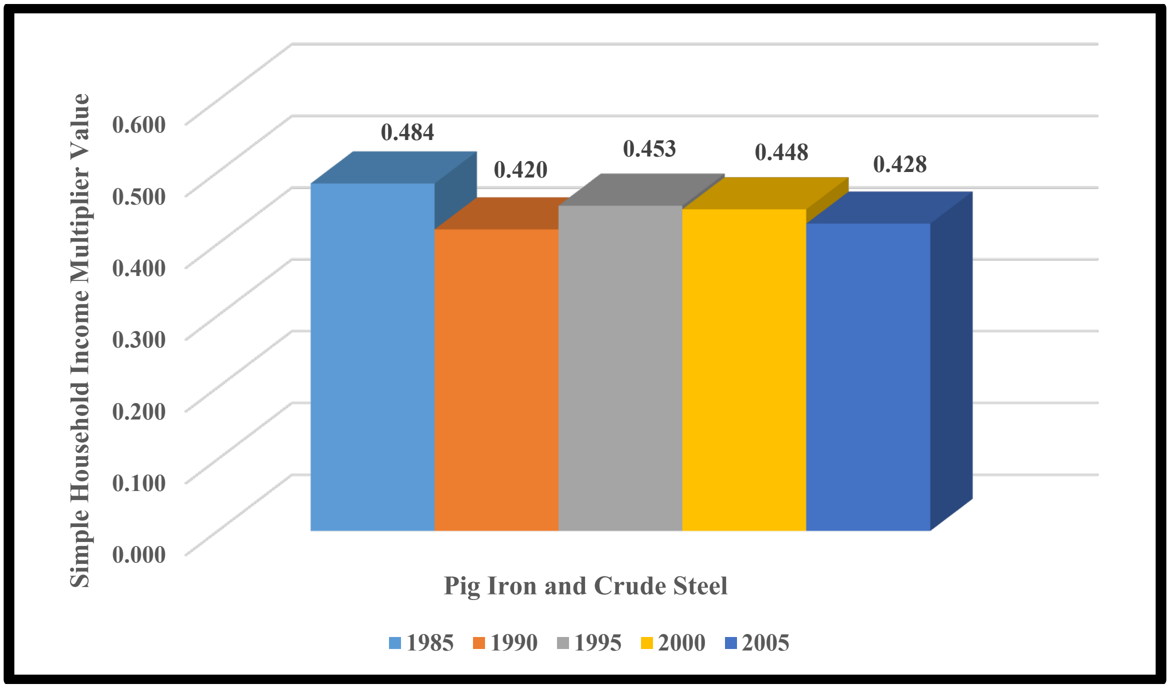

Figure 4. The Simple Household Income Multiplier Values of the Pig Iron and Crude Steel Sector, 1985-2005

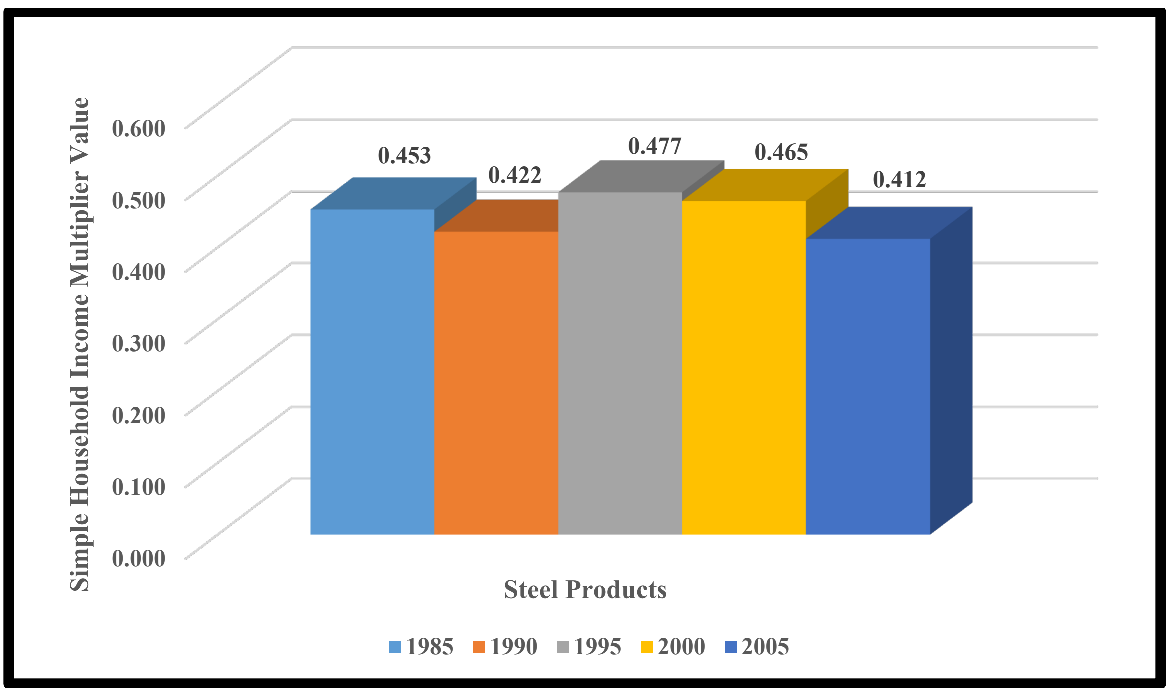

Figure 5. The Simple Household Income Multiplier Values of the Steel Products Sector, 1985-2005

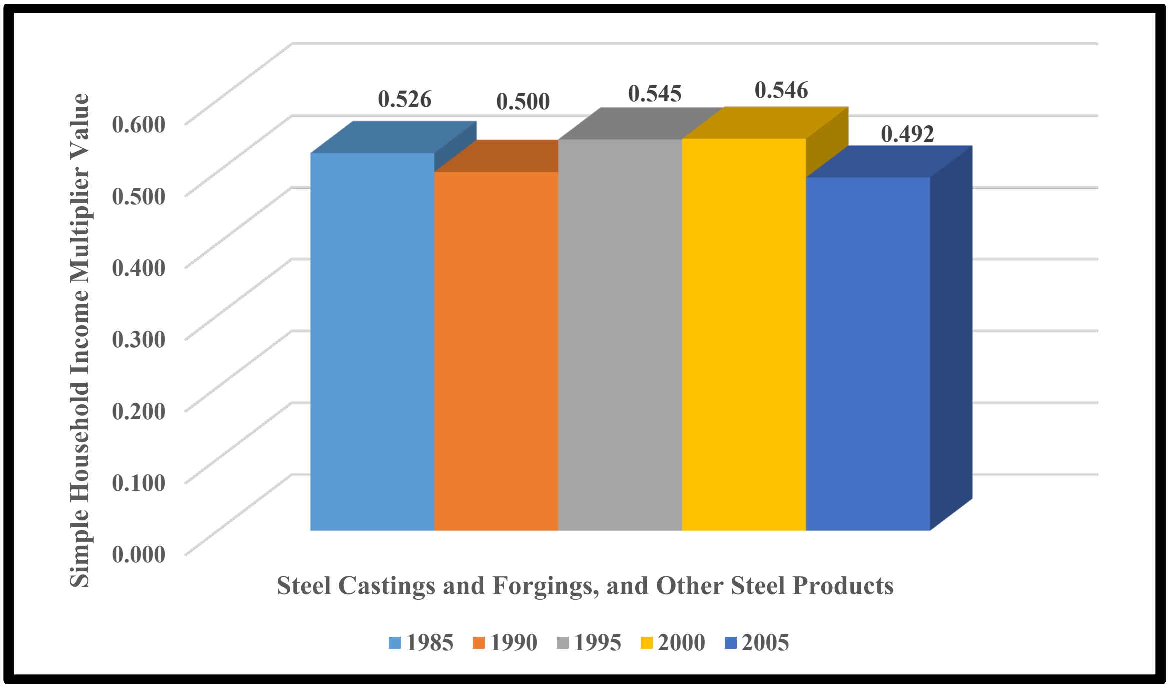

Figure 6. The Simple Household Income Multiplier Values of the Steel Castings and Forgings, and Other Steel Products Sector, 1985-2005

Table 12 reviews the quadrants of analyzed industries on the period of analysis. The quadrants come from the combination of both indices used in this study, namely the index of the power of dispersion and the index of the sensitivity of dispersion. Four quadrants appear from the combination.

Each quadrant has unique attributes. More specifically, quadrant I is a location where the values of both indices are more than one. In other words, the industries lie in this quadrant are those most impacted by the external aspects and have strong effects on the whole industries. The opposite phenomena can be viewed on the industries which lie in quadrant III. On the other hand, quadrant II is a location where the value of the index of the power of dispersion is less than one while the value of the other index is more than one. One can claim that the industries lie in this quadrant are those which have weak impacts on the entire industries, but they get high influences from the alterations of external aspects. The industrial sectors lie in quadrant IV have the opposite characteristics.

Table 12. The Quadrants of Japanese Steel Sectors, 1985-2005

Sector Number	**Sector Name**	**Quadrant**				
		1985	**1990**	**1995**	**2000**	**2005**
35	Pig iron and crude steel	I	I	I	I	I
36	Steel products	I	I	I	I	I
37	Steel castings and forgings, and other steel products	IV	IV	IV	IV	IV

Based on the information in the table, one can claim that the analyzed industries had a consistent pattern regarding the quadrant position on the analysis period. More specifically, pig iron and crude steel, and steel products sectors lied in quadrant I from 1985 through 2005 while steel castings and forgings, and other steel products sector was in quadrant IV on the same period. These facts explain that the analyzed industries had strong impacts on the entire Japanese industries on the period of analysis.

4. Conclusions and Further Researches

This study analyzes the roles of Japanese steel industries in the Japanese national economy by using IO analysis. More specifically, this study employs simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis apparatuses. The analysis period of this study is 1985-2005. The analyzed Japanese steel industries in this study are (1) pig iron and crude steel, (2) steel products, and (3) steel castings and forgings, and other steel products.

The results show that, by using simple output multiplier, one can argue that one of the analyzed industries, steel products, attracted consistently the Japanese economy from 1985 through 2005. The same attractiveness could be seen on pig iron and crude steel sector from 1985 through 1995. By using point of view of simple household income multiplier, one can argue that the analyzed industries did not make the attractive influence to the economy of Japan on the analysis period.

Meanwhile, by using both indices, one can claim that the analyzed industries had a consistent pattern regarding the quadrant location on the period of analysis. More specifically, pig iron and crude steel, and steel products sectors were in quadrant I from 1985 through 2005 while steel castings and forgings, and other steel products sector lied in quadrant IV on the same period. These facts elucidate that the analyzed industries had strong influences on the entire Japanese industries on the analysis period.

The understanding regarding the roles of Japanese steel industries in influencing the Japanese national economy on the analysis period is obtained from the current study. However, the study would gain a broader perception about the roles if the study could analyze the longer analysis period. Therefore, as one of the further studies, the study recommends the same analysis by utilizing the longer period of analysis, such as from 1985 through 2020. One of the important points that must be considered when conducting the recommended further study is the prices and industrial sectors used on the analyzed IO tables should be same.

The other suggested further research from the study is to organize an international comparison using the same approaches. The comparison can be focused on developed-developed, developed-developing, or developing-developing nations. The comparison might explore the roles of the steel industries of compared countries so the similarities and differences among those regarding the industries can be analyzed. One of the examples of the suggested further research is the comparison between Japan and Malaysia.

Acknowledgements

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Appendix

The Japanese Industries (Source: Zuhdi et al. (2014) with Slight Modifications)

Sector Number	Sector Name
1	Crop cultivation
2	Livestock
3	Agricultural services
4	Forestry
5	Fisheries
6	Metallic ores
7	Non-metallic ores
8	Coal mining, crude petroleum, and natural gas
9	Foods
10	Beverage
11	Feeds and organic fertilizer, n.e.c.

12	Tobacco
13	Textile products
14	Wearing apparel and other textile products
15	Timber and wooden products
16	Furniture and fixtures
17	Pulp and paper
18	Paper products
19	Publishing and printing
20	Chemical fertilizer
21	Basic industrial inorganic chemicals
22	Chemical basic and intermediate products
23	Synthetic resins
24	Synthetic fibers
25	Final chemical products, n.e.c.
26	Petroleum refinery products
27	Coal products
28	Plastic products
29	Rubber products
30	Leather, fur skins, and miscellaneous leather products
31	Glass and glass products
32	Cement and cement products
33	Pottery, china, and earthenware
34	Other ceramic, stone, and clay products
35	Pig iron and crude steel
36	Steel products
37	Steel castings and forgings, and other steel products
38	Non-ferrous metals
39	Non-ferrous metal products
40	Metal products for construction and architecture
41	Other metal products
42	General industrial machinery
43	Special industrial machinery
44	Other general machines
45	Machinery for office and service industry
46	Electrical appliance
47	Motor vehicles and repair of motor vehicles
48	Ships and repair of ships
49	Other transportation equipment and repair of transportation equipment
50	Precision instruments
51	Miscellaneous manufacturing products
52	Building construction
53	Repair of construction

54	Civil
55	Electricity
56	Gas and heat supply
57	Water supply
58	Waste management service
59	Commerce
60	Finance and insurance
61	Real estate agencies and rental services
62	House rent
63	Railway
64	Road transport (except transport by private cars)
65	Self-transport by private cars
66	Water transport
67	Air transport
68	Storage facility service
69	Services relating to transport
70	Communication
71	Broadcasting
72	Public administration and activities not elsewhere classified
73	Education
74	Research
75	Medical service, health, and social security
76	Other public services
77	Business and office supplies
78	Personal services

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