



# 2nd Asia Pacific Conference on Industrial Engineering and Operations Management

*-Indonesia*

organizer

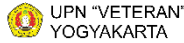


Host University



September 13-16, 2021

# Sponsors and Partners



# Organizer



## IEOM Society

"Achieving and Sustaining Operational Excellence"

[www.ieomsociety.org](http://www.ieomsociety.org)

**Industrial Engineering and Operations Management Society International**

IEOM Society International, 21415 Civic Center Dr., Suite 217, Southfield, Michigan 48076, USA

Phone: 1-248-450-5660, Email: [info@ieomsociety.org](mailto:info@ieomsociety.org)



## Welcoming Message by Host, Universitas Sebelas Maret (UNS)

**Prof. Dr. Kuncoro Diharjo, S.T., M.T.**

*The Vice-Rector for Research and Innovation Affairs*

Universitas Sebelas Maret (UNS), Surakarta, Indonesia

*Honorary Chair of the 2<sup>nd</sup> Asia Pacific Conference on IEOM*

***Assalamu 'alaykum wa rahmatullahi wa barakatuh***

***Ladies and Gentlement,***

It is a great pleasure and an honor for me to deliver this welcome remark at the Opening Ceremony of the 2<sup>nd</sup> Asia Pacific Conference on Industrial Engineering and Operations Management (2<sup>nd</sup> APIEOM), September 13-16, 2021, organized by IEOM Society International and Hosted by Universitas Sebelas Maret. Distinguished guests, 15 outstanding keynote speakers, 30 invited speakers, and 700 presenters technical session from 35 countries in this conference. Welcome to Universitas Sebelas Maret in virtual mode due to the current COVID-19 global pandemic. Welcome to Solo, a city of culture. Solo is the one place where you can feel the Spirit of Java.

Many thanks to the university partners that get involved in this event. They are Diponegoro University; Universitas Islam Negeri (UIN) Sunan Kalijaga Yogyakarta, UPN Veteran Yogyakarta, Telkom University, Tarumanagara University; and *the Indonesian industrial engineering higher education institution cooperation agency* or (BKSTI). This event is a part of the long collaboration with IEOM Society International that was initiated by the academic staffs of the Industrial Engineering Department, Faculty of Engineering, Universitas Sebelas Maret in 2018. I appreciate the supports from the Faculty of Engineering and especially Industrial Engineering Department to join with international collaboration organizations, such as The IEOM Society International, and to conduct and actively participate in international events, such as 2<sup>nd</sup> APIEOM.

***Ladies and Gentlemen,***

These efforts support The Universitas Sebelas Maret's Vision: *"Becoming the excellent center of development of science, technology, and art at international level based on the noble values of the national culture"*. Moreover, 2<sup>nd</sup> APIEOM 2021 will support the line synergy towards UNS as a World Class University, as well as building stronger relationships between universities and industries, globally. Furthermore, we hope this event strengthens the cooperation between Universitas Sebelas Maret and other local and international partner universities. This collaboration should also involve more students in various countries in the world because they will be the successors of us to make a better world.

On behalf of Universitas Sebelas Maret and the Organizing Committee, I officially open **the 2<sup>nd</sup> Asia Pacific Conference on Industrial Engineering and Operations Management**. *"Success is a part of progress, as a reward from moving forward. It is time for Indonesia to go global and be global"*.

Thank you very much. *Terima kasih. Matur nuwun*

***Wassalamu 'alaykum wa rahmatullahi wa barakatuh***

Have a good time to join the conference



## Welcome to the 2<sup>nd</sup> Asia Pacific Conference on Industrial Engineering and Operations Management Surakarta, Indonesia, September 13-16, 2021

**Prof. Dr. Ir. Wahyudi Sutopo, ST., M.Si**  
*Conference Chair & President IEOM Indonesia Chapter*  
 Department of Industrial Engineering, Faculty of Engineering  
 University of Sebelas Maret (UNS), Surakarta, Indonesia

### Greetings Conference Attendees:

On behalf of the IEOM Society International, we would like to welcome you to Surakarta, Indonesia and the Second Asia Pacific **Conference on Industrial Engineering and Operations Management**, September 13-16, 2021. This event host is University of Sebelas Maret (UNS). This prestigious event provides a forum for academics, researchers, and practitioners from many industries to exchange ideas, knowledge and experiences on issues related to changing and dynamic trend in Industrial Engineering and Operations Management. Held annually by IEOM International, this diverse international event provides an opportunity to collaborate and advance the theory and practice, as well as, an healthy competition atmosphere among fellow researchers and students.

Our keynote speakers will address some current issues in Industrial Engineering and Operations Management:



**Dr. Jessika E. Trancik**  
 Massachusetts Institute of Technology, USA



**Dr. Jay Lee**  
 Foxconn Technology Group



**Prof. George Q. Huang**  
 The University of Hong Kong, Hong Kong



**Dr. Robert de Souza**  
 National University of Singapore, Singapore



**Harry Kasuma Aliwarga**  
 UMG Myanmar, Jakarta, Indonesia



**Dr. Ahad Ali**  
 Lawrence Tech, Michigan, USA  
 Executive Director of IEOM



**Prof. Dr. Eng. Koichi Murata**  
 Nihon University, Japan



**Dr. Rajesh Piplani**  
 Nanyang Technological University, Singapore



**Bertha Maya Sopha, PhD**  
 Gadjah Mada University; Chair of BKSTI, Indonesia



**Prof. Anicia Peters**  
 University of Namibia, Windhoek Khomas, Namibia



**Tom Gaasenbeek**  
 Nexas Networks Inc., Ontario, Canada



**Adil Dalal**  
 Operations Enviromedica, Texas, USA



**Dr. John Blakemore**  
 University of Newcastle, Australia



**Dr. Basuki Rahmad**  
 PT Transforma Engineering & Solutions, Indonesia



**Dr. Zain Tahboub**  
 MENA College of Management (MCM) Dubai, UAE

Held concurrently, the 25<sup>th</sup> IEOM Global Engineering Education or Indonesian Engineering Education Conference (IEEC) session will feature distinguished speakers who will discuss workforce readiness and engineering education challenges and opportunities. The 24<sup>th</sup> IEOM Industry Solutions and Industry 4.0 will showcase industry best practices and intelligent integration. IEOM Global Supply Chain and Logistics will address the global logistics challenges due to the worldwide pandemic situation. In addition, several outstanding panel sessions will explore current worldwide issues, such as Halal Supply Chain, Women in Industry and Academia (WIIA), Renewable Energy, Diversity and Inclusion, and Technopreneurship.

The IEOM Society expresses our deep appreciation to the conference organizing committee, international and local organization partners, 15 distinguished keynote speakers, 30 outstanding invited speakers, and 700 paper authors from 35 countries who create a wonderful collaboration in making an overwhelmingly successful event.

**Success is a part of progress, as a reward from moving forward. It is time for Indonesia to go global and be global.**  
 Enjoy the conference!

On behalf of the organizing committee,



**Professor Don Reimer**  
*Director of Membership & Chapter of IEOM Society*  
 Lawrence Technological University, USA



**Dr. Muh. Hisjam**  
*Program Chair*  
 University of Sebelas Maret, Surakarta, Indonesia



**Dwi Agustina Kurniawati, PhD**  
*Program Chair*  
 State Islamic University Sunan Kalijaga, Yogyakarta, Indonesia



**Dr. Manik Mahachandra**  
*Program Chair*  
 Diponegoro University, Semarang, Indonesia

We also thank to the host and local partners:



Universitas Sebelas Maret



Universitas Diponegoro



UIN Sunan Kalijaga



Universitas Tarumanagara



Universitas Pembangunan Nasional "Veteran"



Telkom University



BKSTI

# Conference Program

## Day 1 – September 13 (Monday)

08:00 – 9:45 am Technical Presentations – Zoom Meeting Rooms 1-6  
 10:00 – 11:45 am Technical Presentations – Zoom Meeting Rooms 1-6  
 12:00 – 1:45 pm Technical Presentations – Zoom Meeting Rooms 1-6  
 02:00 – 3:45 pm Technical Presentations – Zoom Meeting Rooms 1-6  
 04:00 – 5:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

## Day 2 – September 14 (Tuesday)

8:00 am – Officially Opening the Conference from UNS Vice Rector – Zoom Meeting Room 1  
 8:20 am – Keynote Speaker I: **Dr. Jessika E. Trancik**, Associate Professor, Institute for Data, Systems and Society (IDSS), Massachusetts Institute of Technology (Opening Keynote) – Zoom Meeting Room 1  
 9:00 am – Keynote Speaker II: **Dr. Jay Lee**, Vice Chairman and Board Member of Foxconn Technology Group, Member of World Economic Forum Global Future Council on Advanced Manufacturing and Production – Zoom Room 1  
 9:40 am – Keynote Speaker III: **Prof. George G. Q. Huang**, Chair Professor and Head, Department of Industrial and Manufacturing, Systems Engineering, The University of Hong Kong – Zoom Meeting Room 1  
 10:20 am Break  
 10:40 am – Keynote Speaker IV: **Dr. Robert de Souza**, The Executive Director of the The Logistics Institute – Asia Pacific (TLI – Asia Pacific), National University of Singapore, Singapore City, Singapore – Zoom Meeting Room 1  
 11:20 am Keynote Speaker V: **Harry Kasuma (Kiwi) Aliwarga**, CEO and Co-Owner, UMG Myanmar – Zoom Meeting Room 1

12:00 pm – LUNCH BREAK

1:00 pm – 2:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6  
 2:45 pm – Break  
 3:00 pm – 4:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6  
 4:45 pm – Break  
 5:00 pm – 6:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

## Day 3 – September 15 (Wednesday)

8:00 am – Conference Co-Chair Remarks – Zoom Meeting Rooms 1  
 8:20 am – Keynote Speaker VI: **Dr. Ahad Ali**, Associate Professor and Director of Industrial Engineering, Lawrence Technological University, Michigan, USA – Zoom Meeting Room 1  
 9:00 am – Keynote Speaker VII: **Prof. Dr. Eng. Koichi Murata**, College of Industrial Technology, Nihon University, Japan – Zoom Room 1  
 9:40 am – Keynote Speaker VIII: **Dr. Rajesh Piplani**, Associate Professor, The school of Mechanical and Aerospace Engineering, Systems and Engineering Management division, Nanyang Technological University, Singapore – Zoom Meeting Room 1  
 10:20 am Break  
 10:40 am – Keynote Speaker IX: **Dr. Ir. Bertha Maya Sopha**, Past Director of Industrial Engineering Undergraduate Program, Faculty of Engineering, Universitas Gadjah Mada (UGM), Yogyakarta, Indonesia and President – Indonesian Association of Industrial Engineering Higher Education Institution (BKSTI) – Zoom Meeting Room 1  
 11:20 am Keynote Speaker X: **Prof. Anicia Peters**, Pro-Vice Chancellor: Research, Innovation & Development, University of Namibia

12:00 pm – LUNCH BREAK

1:00 pm – 2:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6  
 2:45 pm – Break  
 3:00 pm – 4:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6  
 4:45 pm – Break  
 5:00 pm – 6:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

## Day 4 – September 16 (Thursday)

8:00 am – Conference Co-Chair Remarks – Zoom Meeting Rooms 1  
 8:20 am – Keynote Speaker XI: **Tom Gaasenbeek**, Founder and CEO, Nexas Networks Inc., Hamilton, Ontario, Canada – Zoom Meeting Room 1  
 9:00 am – Keynote Speaker XII: **Adil Dalal**, Vice President of Operations, Enviromedica, Austin, Texas, USA – Zoom Meeting Rooms 1  
 9:40 am – Keynote Speaker XIII: **Dr. John Blakemore**, Adjunct Professor at University of Newcastle, Blakemore Consulting International, Sydney, Australia – Zoom Meeting Room 1  
 10:20 am Break  
 10:40 am – Keynote Speaker XIV: **Dr. Basuki Rahmad**, ST, MT, CEO, PT. Transforma Engineering & Solutions, Bandung, Java, Indonesia  
 11:20 am Keynote Speaker XV: **Dr. Zain Tahboub**, President, MENA College of Management (MCM), Dubai, UAE – Zoom Meeting Room 1

12:00 pm – LUNCH BREAK

1:00 pm – 2:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6  
 2:45 pm – Break  
 3:00 pm – 4:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6  
 4:45 pm – Break  
 5:00 pm – 6:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

**8:00 – 10:00 pm, September 16: Conference Awards Ceremony and Announcing Competition Winners**

# Keynote Speakers

## Day 2 – September 14 (Tuesday)

8:00 am, Tuesday, September 14 – **Officially Opening The Conference** – Zoom Meeting Rooms 1

8:20 am, Tuesday, September 14 – **Keynote Speaker I:** (Opening Keynote) – Zoom Meeting Room 1



**Dr. Jessika E. Trancik**  
Associate Professor  
Institute for Data, Systems and Society (IDSS)  
Massachusetts Institute of Technology  
Boston, Massachusetts, USA

**Jessika Trancik:** Jessika Trancik is an associate professor in the Institute for Data, Systems, and Society at the Massachusetts Institute of Technology. Her research examines the dynamic costs, performance, and environmental impacts of energy systems to inform climate policy and accelerate beneficial and equitable technology innovation. Her projects focus on all energy services including electricity, transportation, heating, and industrial processes. This work spans solar energy, wind energy, energy storage, low-carbon fuels, electric vehicles, and nuclear fission among other technologies. Prof. Trancik received her B.S. from Cornell University and her Ph.D. from the University of Oxford as a Rhodes Scholar. She is currently an external professor at the Santa Fe Institute, and was formerly at Columbia University's Earth Institute, and at WSP International/UNOPS (now Interpeace) in Geneva. Her work has been published in journals such as *Nature Climate Change*, *Nature*, *Energy Policy*, *Proceedings of the National Academy of Sciences*, and *Environmental Science and Technology*, and has been featured by news outlets such as the *New York Times*, *Financial Times*, *Washington Post*, and *NPR*.

9:00 am, Tuesday, September 14 **Keynote Speaker II:** – Zoom Meeting Room 1



**Dr. Jay Lee**  
Vice Chairman and Board Member of Foxconn Technology Group  
Member of World Economic Forum Global Future Council on Advanced Manufacturing and Production

**Keynote Title: *Industrial AI and Resilient Manufacturing Systems – Technologies, Challenges and Research Issues***

Dr. Jay Lee is Vice Chairman and Board Member of Foxconn Technology Group. Prior to this position, he served as Vice Chairman of Foxconn Industrial Internet. Currently, he is on leave from Univ. of Cincinnati where he holds Ohio Eminent Scholar and L.W. Scott Alter Chair Professor and is the founding director of National Science Foundation (NSF) Industry/University Cooperative Research Center (I/UCRC) on Intelligent Maintenance Systems ([www.imscenter.net](http://www.imscenter.net)). In addition, he is the Founding Director of Industrial AI Center ([www.iaicenter.com](http://www.iaicenter.com)).

He also serves as a member of the Global Future Council on Advanced Manufacturing and Production of the World Economics Forum (WEF) as well as a member of Board of Governors of the Manufacturing Executive Leadership Council of National Association of Manufacturers (NAM) to engage the global leaders for the development of collaborative activities in smart manufacturing.

Previously, he served as senior advisor to McKinsey & Company. Prior to his academic career, he served as Director for Product Development and Manufacturing at United Technologies Research Center (UTRC) as well as Program Directors for a number of programs at NSF. He was selected as 30 Visionaries in Smart Manufacturing in by SME in Jan. 2016 and 20 most influential professors in Smart Manufacturing in June 2020. His new book on Industrial AI was published by Springer in 2020.

For publication citation and impacts, see

- Google Scholar <https://scholar.google.com/citations?user=g9GtqgQAAAAJ&hl=en&oi=ao>
- ResearchGate [https://www.researchgate.net/profile/Jay\\_Lee10](https://www.researchgate.net/profile/Jay_Lee10)

09:40 am, Tuesday, September 14 – **Keynote Speaker III:** – Zoom Meeting Room 1



**Prof. George Q. Huang**  
Chair Professor of Industrial and Systems Engineering  
Head of Department  
Director of HKU-ZIRI Laboratory of Physical Internet  
Department of Industrial and Manufacturing Systems Engineering  
The University of Hong Kong, Hong Kong, China

Prof. George G.Q. Huang is Chair Professor and Head of Department in Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong. He gained his BEng and PhD in Mechanical Engineering from Southeast University (China) and Cardiff University (UK) respectively. He has conducted research projects in the field of Physical Internet (Internet of Things) for Manufacturing and Logistics with substantial government and industrial grants. He has published extensively including over two hundred refereed journal papers in addition to over 200 conference papers and ten monographs, edited reference books and conference proceedings. His research works have been widely cited in the relevant field. He serves as associate editors and editorial members for several international journals. He is a Chartered Engineer (CEng), a fellow of ASME, HKIE, IET and CILT, and member of IIE.

Prof. George G.Q. Huang has been serving on editorial boards of a number of international journals. He is Editor for Asia Pacific for International Journal of Computer Integrated Manufacturing, Associate Editor of International Journal of Production Research, Area Editor for Business & Management for International Journal of Research in Engineering Design, and Associate Editor for Journal of Intelligent Manufacturing.

Prof. George G.Q. Huang received 2014 First-Class Guangdong Province (Department of Science and Technology) on "Mass-Customized Design and Production System", 2007 First-Class Natural Science Award from Chinese Ministry of Education on "Service-oriented manufacturing execution in extended enterprises", 2007 Outstanding Young Researcher Award (Overseas) from Natural Science Foundation of China and 2001 The University of Hong Kong Outstanding Young Researcher Award.

10:20 am – BREAK

10:40 am, Tuesday, September 14 – **Keynote Speaker IV:** – Zoom Meeting Room 1



**Dr. Robert de Souza**  
The Executive Director  
The Logistics Institute – Asia Pacific (TLI – Asia Pacific)  
National University of Singapore, Singapore City, Singapore

Dr. Robert de Souza is the Executive Director of the The Logistics Institute – Asia Pacific (TLI – Asia Pacific). Robert is a Chartered Engineer and a distinguished writer, speaker, consultant and advisor in the area of supply chain management. Prior to this appointment, effective May 1st 2004, Dr Robert de Souza served as Deputy Executive Director (Industry) and IT Director at TLI – Asia Pacific. Previously, Dr de Souza was Executive Vice President (Asia Pacific) for V3 Systems. His extensive tenure in the industry also includes serving as the Corporate Senior Vice President and Global Chief Knowledge Officer at Viewlocity Inc. and co-founder, Vice Chairman and CEO of SC21 Pte, Ltd., a Singapore-based supply chain software firm. As an educator, Dr de Souza is an Adjunct Professor in the School of Industrial and Systems Engineering at Georgia Institute of Technology in Atlanta and also a Senior Fellow in the Department of Industrial and Systems Engineering at the National University of Singapore and has previously served as a professor and in several senior positions in the School of Mechanical and Production Engineering at Nanyang Technological University in Singapore. Dr. de Souza is a member of the Editorial Boards of the International Journal of Computer Integrated Manufacturing and the International Journal of Logistics Research and Applications. Dr de Souza also serves on the Advisory Panel of The Chartered Institute of Logistics and Transport, Singapore (CILTS), as a Council Member of the Singapore eSupply Chain Management (eSCM) Council and on the Boards of Directors/Advisors of several IT-

based corporations.

11:20 am, Tuesday, September 14 – **Keynote Speaker V:** – Zoom Meeting Room 1



**Harry Kasuma (Kiwi) Aliwarga**  
Chief Executive Officer and Co-Owner  
UMG Myanmar  
Karet Kuningan Jakarta, Indonesia

Harry Kasuma (Kiwi) Aliwargais chief executive officer and co-owner of UMG Myanmar, one of the country's leading business conglomerates. Born in Jakarta, Indonesia, Mr. Aliwarga graduated from the Institute of Technology of Indonesia (ITI) in 1992 with a degree in industrial engineering and later received a master's degree in civil engineering at the Asia Institute of Technology in Thailand. Kiwi Aliwarga began his professional career in the business development division at Astra International, one of Indonesia's largest traded companies, where he worked from 1992 to 1995. He went to become business development manager at United Tractors-Indonesia (UT) before founding UMG Myanmar in 1998 with his partner MarLar Win. Mr. Aliwarga has set the ambitious goal of making UMG a billion-dollar company by 2020, by relying on three essential pillars: people, leadership, and the relentless pursuit of excellence.

### Day 3 – September 15 (Wednesday)

8:00 am, Tuesday, September 14 – Conference Co-Chair Remarks – Zoom Meeting Rooms 1

8:20 am, Wednesday, September 15 – **Keynote VI:** (Opening Keynote) – Zoom Meeting Rooms 1



**Ahad Ali, Ph.D.**  
Associate Professor  
Director, Bachelor of Science in Industrial Engineering  
Director, Master of Science in Industrial Engineering  
Director, Graduate Certificate in Lean Six Sigma  
Director, Smart Manufacturing and Lean Systems Research Group  
Coordinator, Siemens Electro-Matic Industrial Engineering Lab  
A. Leon Linton Department of Mechanical, Robotics and Industrial Engineering  
Lawrence Technological University  
Southfield, Michigan, MI 48075, USA  
Executive Director – IEOM Society International

**Ahad Ali** is an Associate Professor and Director of Industrial Engineering Program and Director of Smart Manufacturing and Lean Systems Research Group, A. Leon Linton Department of Mechanical, Robotics and Industrial Engineering at the Lawrence Technological University, Southfield, Michigan, USA. He earned B.S. in Mechanical Engineering from Khulna University of Engineering and Technology, Bangladesh, Masters in Systems and Engineering Management from Nanyang Technological University, Singapore and Ph.D. in

Industrial Engineering from University of Wisconsin-Milwaukee. Dr. Ali was Assistant Professor in Industrial Engineering at the University of Puerto Rico – Mayaguez, Visiting Assistant Professor in Mechanical, Industrial and Manufacturing Engineering at the University of Toledo and Lecturer in Mechanical Engineering at the Bangladesh Institute of Technology, Khulna. He received an Outstanding Professor Award of the Industrial Engineering Department, University of Puerto Rico -Mayaguez, (2006-2007). He has published 50 journal and 121 conference papers. Dr Ali has conducted research projects with Chrysler, Ford, DTE Energy, New Center Stamping, Whelan Co., Delphi Automotive System, GE Medical Systems, Harley-Davidson Motor Company, International Truck and Engine Corporation (ITEC), National/Panasonic Electronics, and Rockwell Automation. His research interests include manufacturing systems modeling, simulation and optimization, intelligent scheduling and planning, artificial intelligence, predictive maintenance, e-manufacturing, and lean manufacturing. He has successfully advised seven doctoral students. Dr. Ali has involved with many international conference committees. He is serving as an Executive Director of IEOM Society International and Conference Co-Chair of the International Conference on Industrial Engineering and Operations Management and hold events in Dhaka, Kuala Lumpur, Istanbul, Bali, Dubai, Orlando, Detroit, Rabat, UK, Bogota, Paris, Washington, DC, Pretoria, Bangkok, Pilsen, Toronto, Costa Rica, Sao Paulo and Riyadh. Dr. Ali has visited 20 countries for professional events. He is a member of IEOM, INFORMS, SME and IEEE.

09:00 am, Wednesday, September 15 – **Keynote Speaker VII:** – Zoom Meeting Rooms 1



**Dr. Eng. Koichi Murata**

Head of Operations & Production Management Laboratory  
Professor at the Department of Industrial Engineering and Management  
College of Industrial Technology  
Nihon University, Japan

Koichi Murata is the head of operations & production management laboratory and a professor at the Department of Industrial Engineering and Management, College of Industrial Technology, Nihon University. After graduating Waseda University, he worked as an industrial engineer at Murata Manufacturing Co., Ltd., which is a global leader mainly in the manufacturing of electronic component. His research interests include operations & production management, kaizen, lean management, visual management, technology transfer, knowledge management, sustainable supply chain and others. Dr. Murata takes Editorial Board Member of some international journals, Advisory Board Member in international conferences, and has published articles in international academic journals such as Sustainability, International Journal of Production Research, Journal of the Operations Research Society of Japan, and others. He was interviewed for NHK (Japan broadcasting corporation) and the Associated Press (American news agency) about future society & industry.

09:40 am, Wednesday, September 15 – **Keynote Speaker VIII:** – Zoom Meeting Room 1



**Dr. Rajesh Piplani**

Associate professor  
The school of Mechanical and Aerospace Engineering,  
Systems and Engineering Management division,  
Nanyang Technological University  
Singapore

Dr. Rajesh Piplani is the director of M.Sc. (Supply Chain & Logistics) program at NTU. He obtained his M.S. in Industrial Engineering from Arizona State University in 1990, and his Ph. D. from Purdue University in 1995. Dr. Piplani is listed in Marquis Who is Who in Science and Engineering in USA (1998-1999). He has over seven years of industry experience in India and USA in the areas of Supply-chain management and production planning of power plant equipment and semiconductor fabrication facilities. Since 1998, he has been on the faculty of NTU. He is Program Manager, Integrated Manufacturing and Service Systems (IMSS) for Singapore funding agency A\*Star, managing the SGD 8 Million program. He is an associate consultant with Y3 Technologies. He also sits on the eSCM council of Singapore Manufacturers Association and council of Supply Management Institute of Germany. Dr. Piplani's interests are in the area of supply chain management of manufacturing enterprises, supply chain coordination, reverse logistics and design and analysis of manufacturing systems.

10:20 am – BREAK

10:40 am, Wednesday, September 15 – **Keynote Speaker XIV:** – Zoom Meeting Room 1



**Bertha Maya Sopha, Ph.D.**

Associate Professor and Former Director of Industrial Engineering  
Universitas Gadjah Mada, Indonesia  
Chair of Indonesian Association of Industrial Engineering Higher Education Institution (BKSTI)

Bertha Maya Sopha is an Associate Professor of Industrial Engineering Program, Department of Mechanical and Industrial Engineering, Universitas Gadjah Mada, Indonesia. She was a former head of the Laboratory of Supply Chain Engineering and Logistics in 2013-2015, and a former director of Industrial Engineering Undergraduate Program in 2016-2021. She currently serves as a chair of Indonesian Association of Industrial Engineering Higher Education Institution (BKSTI). She earned Bachelor of Engineering (best graduate) from Universitas Gadjah Mada, a master's degree of Management of Production specialization on Transportation and Logistics (graduate with distinction) from the Department of Industrial Economics and Technology Management, Chalmers University of Technology, Sweden. She holds a PhD from the Industrial Ecology Programme, Norwegian University of Science and Technology (NTNU), Norway. She has maintained a high quality of research throughout her academic career including international scholarly leadership in the areas of supply chain management and logistics, industrial ecology, and complex system modelling. She has been invited as a keynote speaker and given public lectures at symposiums and international conferences in Indonesia and abroad universities. She has also received various academic achievements, awards, and recognitions such as the Best Lecturer runner-up at Universitas Gadjah Mada, best paper awards at several international and national conferences, and research grantee awards from both Indonesia and abroad institutions. She has



professional and community engagement activities to contribute significantly to improve the university's reputation through industrial projects and community services. She has conducted research project with SINTEF Industrial Management (Norway), ENOVA SF (Norway), PT Pos Indonesia, Toyota Motor Manufacturing Indonesia, Boeing USA, PT Perusahaan Gas Negara, Regional Disaster Management Agency, and Ministry of Transportation, and Ministry of Industry. She has also been active as journal reviewers in both reputable international journals and national journals. She has also held an intellectual property on Simulasi Logistik Kebencanaan Merapi (SILOKA) (Simulation of Merapi Disaster Logistics).

11:20 am, Wednesday, September 15 – **Keynote Speaker X** – Zoom Meeting Room 1



**Anicia Peters, PhD**

**Pro-Vice Chancellor: Research, Innovation and Development, University of Namibia**  
**Chairperson: Namibia Presidential Task Force on the Fourth Industrial Revolution**  
**Deputy Chairperson: Namibia Qualifications Authority (Namibia)**  
**Council member: National Council for Higher Education in Namibia**  
**President: Windhoek ACM SIGCHI local chapter**

Anicia Peters is the Pro-Vice Chancellor for Research, Innovation and Development and an Associate Professor of Human Computer Interaction at the University of Namibia. She was also appointed in July 2021 by the President of Namibia as the Chairperson of the 4IR Task Force and has to complete a country assessment and organize the National AI Conference in early 2022. Anicia is further the Technical Programme Committee Chair for ACM CHI 2023 and case studies co-chair for ACM CHI conference 2022. She worked previously at Intuit and Oregon State University in the United States and pursued her PhD at Iowa State University. She was formerly the Executive Dean for the Faculty of Computing and Informatics at the Namibia University of Science and Technology. She is the co-founder of the AfriCHI conference series (Africa Human Computer Systems Conference) and also a co-inventor of the GenderMag method which detects gender inclusiveness issues in software design/development. In June 2021, she initiated an AI Agriculture Start-Up incubation programme at the University of Namibia. She also implemented the Namibia-India Centre of Excellence in IT focusing on Cybersecurity and Big Data and expanding to AI and co-established an Inclusive Collaborative Tech Innovation Hub. Anicia has received a number of accolades for her work in research and social justice. She established 6 student organisations in the United States and in 2015, she received a Presidential White House Award as co-founder of the ISU Womyn of Colour Network. She further received among others research merit awards from Boeing, Iowa State University and the Rector's medal at the Namibia University of Science and Technology; is one of 10 female African rolemodels for Information Technology; received a Next Einstein Advancing Women in STEM award; 2022 IEOM Distinguished Educator award; was a Google scholar and received a 2020 Google AI Inclusion Research Award. In 2019, she was selected as the UNESCO Chair for Gender and Digital Technologies but relinquished it when she left the Namibia University of Science and Technology. Her research focus is social computing, gamification, e-participation such as digital health, gender and e-government. Anicia published over 80 articles.

**Day 4 – September 16 (Thursday)**

8:00 am, Thursday, September 16 – Conference Co-Chair Remarks – Zoom Meeting Room 1

8:20 am, Thursday, September 16 – **Keynote Speaker XI** – Zoom Meeting Room 1



**Tom Gaasenbeek**

**Founder and CEO, Nexas Networks Inc.**  
**Hamilton, Ontario, Canada**

Tom Gaasenbeek is the Founder and CEO of Nexas Networks Inc. and five other companies over the last 29 years. Nexas is a Canadian based high-tech Company that specializes in leading-edge manufacturing connectivity solutions for the shop floor. Since he co-founded Memex Electronics Inc. in 1992, Tom has been the visionary leader, and CTO dedicated to “internetworking” machine tools on the factory floor. Under Tom’s leadership, his engineering teams successfully developed technologies that open closed CNC control architectures (such as Fanuc), and he was installing his embedded IoT solutions in the marketplace already when the term was coined in 1998. Starting as a member of the Open Modular Architecture Controls Group (OMAC) in 1998, Tom led the Global HMI development team from his public company e-Manufacturing Networks, which created the first machine tool XML schema for HMI, OEE and Lean Manufacturing applications in 1999 that is today called MTConnect. Tom has filed patents in the area of Energy Management and Dynamic Computer Assisted Machining (DCAM), authored numerous articles in trade journals Industry 4.0 and IIoT areas, and spoken at AI conferences as to its importance in the manufacturing sector. Further, Tom has been a speaker about the adoption of AI and AR on the factory floor as well. In 2018, Mr. Gaasenbeek was named to the Top 50 in North America by Smart Industry Magazine for his co-founding of the widely adopted ANSI standard called “MTConnect”. Tom also authors a blog called “CIM Today” that promotes Computer Integrated Manufacturing, and it has had over 70,000 readers since it started. Also since 2013, Tom has been the Executive Director of the Advanced Technology Think Tank which was founded in 1962. Tom works with McMaster Manufacturing Research Institute in Hamilton and Concordia University in Montreal at the moment.

09:00 am, Thursday, September 16 – **Keynote Speaker XII:** – Zoom Meeting Room 1



**Adil Dalal**  
Vice President of Operations  
Enviromedica  
Austin, Texas, USA

Adil is an executive leader with 30+ years of experience developing and delivering pioneering, customized enterprise-wide digital solutions across industries in North America, Europe, Asia, Africa, Middle-East and Latin America. He has led over 350 strategic and tactical lean six sigma, digital transformation, leadership development, software development, factory re-layouts and mergers and acquisition programs globally across various industries. Adil has coached global executives and government leaders to enhance the value of human potential, and optimize ROI through enhanced performance of leaders, and individuals. He is also a distinguished global keynote speaker, award-winning author in lean, quality and business optimization, and the recipient of '2014 Global Award for Outstanding contribution to Quality & Leadership'. Adil's book 'The 12 Pillars

of Project Excellence: A Lean Approach to Improving Project Results' has won the ASQ Crosby Zero-defect Medal, the Shingo Research & Publication Award, and the Axiom Best Business Book Award. He has also, authored 'A Legacy Driven Life: Live a Legacy to Leave a Legacy' and co-authored ASQ's 'Lean Bronze Certification Handbook'. Adil has pioneered innovations like Sensei Leadership™, iLean@ Technology, iCulture™, The V-Factor™ and Pinnacle Performance Zone™. His mastery has made him a sought after strategic solutions partner, coach, and an executive sensei.

09:40 am, Thursday, September 16 – **Keynote Speaker XIII:** – Zoom Meeting Room 1



**Dr. John Blakemore**  
Adjunct Professor at University of Newcastle  
Blakemore Consulting International  
Sydney, Australia

#### **Industry 4.0 and its Vision**

Dr. Professor John Blakemore originally completed a part time BSc in Metallurgy while working in the steel industry. Later he won an International Scholarship to study a PhD on the electronic structure of metals and alloys and the effect of nuclear irradiation and hydrogen. He was then employed as a Research Scientist at the Atomic Energy Commission and later Chief Metallurgist (R&D). His team developed numerous world first ideas and processes and also the first advanced quality system for defence purposes in Australia in 1981. Earlier work with his team led and assisted in the successful commercialisation of Zinalume coated steel called

Colorbond. He set up his own company in 1982 and then developed and helped commercialise a range of processes including two new galvanizing processes, and a new process for Aluminium filtration. He has successfully improved concrete manufacture plastic extrusion, Aluminium casting, welding operations and structural steel manufacture. He had a wide range of International clients including, Panasonic, Canon, Honda, Speedo, CSIRO, BHP, Alcatel, Duracell, Cochlear, Pirelli and others. He wrote the first course in Lean Manufacturing in Australia in 1991, and the first course in Industrial Arts in 1977 and has authored 6 books. He has taught part time at various universities from 1964. His most recent work was leading a team of mathematicians and scientists and engineers successfully prototyping a new scanning device for cervical cancer. He also invented a new surgical procedure to save his own eyesight in 1991. He was the National President of the Australian Manufacturing Society, and has served on numerous boards and is the fellow of numerous professional societies. Currently he is working at the University of Newcastle and assisting a company developing a new tufting process for carpet and researching his next book.

10:20 am – BREAK

10:40 am, Thursday, September 16 – **Keynote Speaker XIV:** – Zoom Meeting Room 1



**Dr. Basuki Rahmad, ST, MT**  
CISA, CISM, CRISC, CDPSE, TOGAF, CITAF, COBIT5-I, CSXF, ITILF, CDCP, CBDA  
CEO PT.  
Transforma Engineering & Solutions  
Bandung, Indonesia

Basuki Rahmad is the founder of TRANSFORMA, a company with a primary focus on digital transformation, enterprise architecture, IT GRC, IT Security/Assurance; and several startups on IT Solution, Business Analytics, Open Infrastructure and HVAC/Energy Management.

Basuki Rahmad has over 20 years of industry and consulting experience in analyzing the organization digital challenge, architecting the strategy and enterprise architecture, developing an innovative digital operating model and assisting the digital change management. Beside leading his group of companies, Basuki has also been appointed as an IT Advisor in several state-owned enterprises (BUMN) and also a senior consultant at the World Bank. His key experiences include organizing digital transformation in several BUMN holdings and several ministries, including enterprise architecture and IT/data governance related to it.

Basuki Rahmad completed his undergraduate, master's and doctoral education at the School of Electrical and Informatics Engineering, Institut Teknologi Bandung (ITB). Regarding academic activities, he is currently a professional lecturer and researcher at Telkom University.

# Indonesian Construction Sectors: An Analysis from the Economic Perspective

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## Abstract

The purpose of this study is to analyze the roles of construction sectors in the Indonesian national economy. This study uses Input-Output (IO) analysis as an analysis device. More specifically, this study employs 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 tools. The analysis period of this study is 1990-2005. In this study, the analyzed sectors are (1) construction on agriculture, (2) public work on road, bridge, and harbor, (3) construction and installation on electricity, gas, water supply, and communication, and (4) other construction. The results show that, by using both multipliers, the analyzed construction sectors did not include in the top five Indonesian industrial sectors from 1990 through 2005. By using both indices, the analyzed industries almost always occupied the quadrant IV on the period of analysis.

## Keywords

Construction Sectors, National Economy, IO Analysis, Patterns.

## 1. Introduction

The industrial sectors have an important role in a national economy. They contribute not only on the micro aspect, but also on the macro aspect of a country. Their contribution can be seen both in developed and developing countries. One of the industries that worth to be discussed in this matter is the construction sector.

There are many previous studies discuss the contribution or role of the construction industry in the economy. For example, Bosch-Sijtsema and Gluch (2019) make an understanding of the agency and role of Building Information Modelling (BIM) players by applying the theoretical construct of institutional work. Zhang (2019) explores the text mining algorithms for the classification of automatic construction accident causes. Schönbeck et al. (2020) conduct the study to get two main things, namely (1) the information needed to control changes on the period of the healthcare construction projects, and (2) the available needed information in the current change management within the projects on the healthcare construction. Wernicke et al. (2021) construct a basis for measuring digital maturity of construction site operations.

Besides, Sezer and Bosch-Sijtsema (2020) investigate barriers and tensions between players within the service ecosystem of Construction and Demolition Waste (CDW) for the Swedish refurbishment projects. Sobieraj and

Metelski (2020) differentiate a number of factors that allow for a better understanding of investment process management in the industry of housing construction. Their study focuses on the case of Poland. Rondinel-Oviedo (2021) conducts the study which focuses on the status of the management of CDW in the Lima Metropolitan Area (LMA) for diagnosing the different phases in the management.

Based on the aforesaid previous studies, the study to analyze the economic aspect of the construction industry is still needed. This study is conducted to fulfill the gap. One of the tools in conducting the analysis is Input-Output (IO) analysis, the device in investigating the linkages of industrial sectors in one or more countries. The importance and originality of this study are that it explores the roles of the industry by applying several calculation methods from IO analysis which focusing on the national economy of Indonesia.

The purpose of this study is to analyze the roles of construction industries in the national economy of Indonesia. This study employs IO analysis as an analysis device. 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 tools. The analysis period of this study is 1990-2005.

The rest of this paper is explained as follows. Section 2 shows the methodology of this study. Section 3 describes the results of calculations. Also, the discussions for the results can be viewed on this section. The next section, section 4, explains the conclusions of this study, and suggested further studies.

## 2. Methodology

The methodology of this study is described as follows. The first step is to explain the data used. This study uses Indonesian IO tables for 1990, 1995, and 2005 as data. Initially, the tables consist of 161, 172, and 175 industrial sectors, respectively. After conducting the adjustment process, the tables have 159 industries. Those industries are described in Appendix. The second step is to show the Indonesian construction sectors used in this study. Table 1 shows those sectors.

The next step is to conduct the calculations by applying simple output multiplier, and simple household income multiplier. Miller and Blair (2009) describe the equations of both multipliers as follows:

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

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

The former model describes the simple output multiplier while the latter one explains 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 sectors, and a sector-to-sector multipliers matrix, respectively.

Table 1. Indonesian Construction Sectors Used in This Study

Sector Number	Sector Name
133	Construction on agriculture
134	Public work on road, bridge and harbor
135	Construction and installation on electricity, gas, water supply and communication
136	Other construction

The fourth step is to conduct the calculations in order to analyze the characteristics of Indonesian industrial sectors on the analysis period, especially the Indonesian construction industries. The methods applied in the calculations are the (1) index of the power of dispersion, and (2) index of the sensitivity of dispersion. The former index is used to analyze the strength of one specific industry in influencing entire industries. A greater influence is aligned with the higher

index value. The detail of the index is explained by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

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

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

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

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

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 utilized to analyze the sensitivity of the specific industry to the external influences. A greater sensitivity is aligned with the greater index value. More specifically, one particular industrial sector is called more sensitive to the influences from the external aspects if it has a higher index value. The detail of the index is described by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

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

In this index, the numerator is each sum of row in the table of inverse matrix coefficients while the denominator describes 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 explained as follows:

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

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

In order to get a compatibility sense with the previous index, equation (7) is slightly changed from the original source. More specifically, the part describes the total number of discussed industrial sectors,  $n$ , 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 explained on the last step.

### 3. Results and Analysis

Tables 2, 3, and 4 show the top five Indonesian industrial sectors observed from the value of simple output multiplier in 1990, 1995, and 2005, respectively. Miller & Blair (2009) explain 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 fulfill a currency's worth of final demand for the output of sector  $j$ . They also describe that, for the simple output multiplier, the total value of production is coming from the model of households exogenous.

Analyzed construction sectors do not include in the tables. By using this result, one can argue that the sectors did not generate the attractive impact to the economy of Indonesia on the analysis period through an additional final demand. Another interesting point from the multiplier is the sectors 66, 111, and 112 can be seen in tables. Those sectors are made up textile goods except wearing apparel, prime movers engine, and machinery and apparatus, respectively. This fact describes the consistency of the sectors in attracting the Indonesian economy from 1990 through 2005. Machinery and apparatus sector occupies the first rank in table 4 which the value is 3.004. This value indicates that in order to satisfy a rupiah's worth of final demand for the sector's output in 2005, all Indonesian industries needed to produce the products which the total value was Rp 3.004.

Table 2. Top Five Indonesian Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1990  
 (Source: Zuhdi (2014) with Slight Modifications)

No.	Sector Number	Sector Name	Simple Output Multiplier
1	97	Plastic products	2.973
2	112	Machinery and apparatus	2.943
3	66	Made up textile goods except wearing apparel	2.779
4	68	Wearing apparel	2.692
5	111	Prime movers engine	2.685

Table 3. Top Five Indonesian Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1995  
 (Source: Zuhdi (2014) with Slight Modifications)

No.	Sector Number	Sector Name	Simple Output Multiplier
1	124	Aircraft and its repair	2.792
2	112	Machinery and apparatus	2.777
3	66	Made up textile goods except wearing apparel	2.737
4	68	Wearing apparel	2.685
5	111	Prime movers engine	2.623

Table 4. Top Five Indonesian Industrial Sectors Viewed from the Value of Simple Output Multiplier, 2005  
 (Source: Zuhdi (2014) with Slight Modifications)

No.	Sector Number	Sector Name	Simple Output Multiplier
1	112	Machinery and apparatus	3.004
2	124	Aircraft and its repair	2.992
3	111	Prime movers engine	2.809
4	127	Musicals instruments	2.608
5	66	Made up textile goods except wearing apparel	2.595

Figure 1 shows the simple output multiplier values of analyzed industries on the period of analysis. Based on the figure, one can say that the analyzed industries have same pattern, namely value decreasing could be seen from 1990 through 1995 while the opposite phenomenon was happened between 1995 and 2005. This fact might be influenced by the financial crisis that hit Indonesia in 1997-1998.

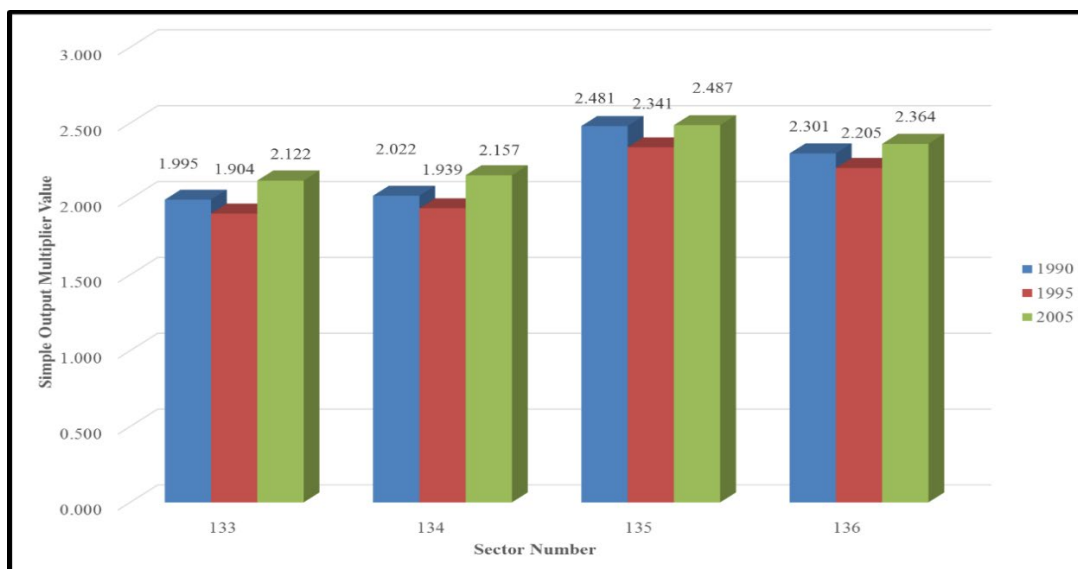


Figure 1. The Simple Output Multiplier Values of Analyzed Industries, 1990-2005

Tables 5, 6, and 7 explain the top five Indonesian industrial sectors viewed from the value of simple household income multiplier in 1990, 1995, and 2005, respectively. Miller & Blair (2009) describe that the multiplier is applied to explain the economic impacts of new final demand as measured by new households income by using the model of households exogenous. Based on the information in the tables, one can say that only one sector that appears in both multipliers, namely musical instruments, the sector number 127.

Table 5. Top Five Indonesian Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1990 (Source: Zuhdi (2015) with Slight Modifications)

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	151	General government	0.952
2	154	Other community services	0.629
3	152	Education services	0.579
4	11	Rubber	0.523
5	140	Railway transport	0.519

Table 6. Top Five Indonesian Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1995 (Source: Zuhdi (2015) with Slight Modifications)

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	151	General government	0.758
2	152	Education services	0.666
3	154	Other community services	0.659
4	11	Rubber	0.523
5	127	Musicals instruments	0.508

Table 7. Top Five Indonesian Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 2005 (Source: Zuhdi (2015) with Slight Modifications)

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	151	General government	0.643
2	154	Other community services	0.602
3	152	Education services	0.598
4	11	Rubber	0.477
5	155	Private motion picture and its distribution	0.454

As with the previous multiplier, the analyzed industries do not include in simple household income multiplier tables too. One of the interesting points from this multiplier is the compositions of the related tables are similar. More specifically, there are four industries that appear in each table that related to the multiplier, namely (1) general government, (2) other community services, (3) education services, and (4) rubber. In 2005, the values of those sectors were 0.643, 0.602, 0.598, and 0.477, respectively. These values indicate that, in 2005, an additional rupiah of final demand for the sectors would generate Rp 0.643, Rp 0.602, Rp 0.598, and Rp 0.477 of new household incomes, respectively, when all direct and indirect impacts were changed into rupiah estimates of incomes. Another interesting point is the first position of the tables is owned by the sector number 151, general government.

Figure 2 explains the simple household income multiplier values of analyzed industrial sectors on the analysis period. Based on the figure, one can argue that the analyzed industries have same pattern, namely value increasing appeared from 1990 through 1995 while the opposite phenomenon could be seen between 1995 and 2005. This pattern is different with the one owned by the previous multiplier.

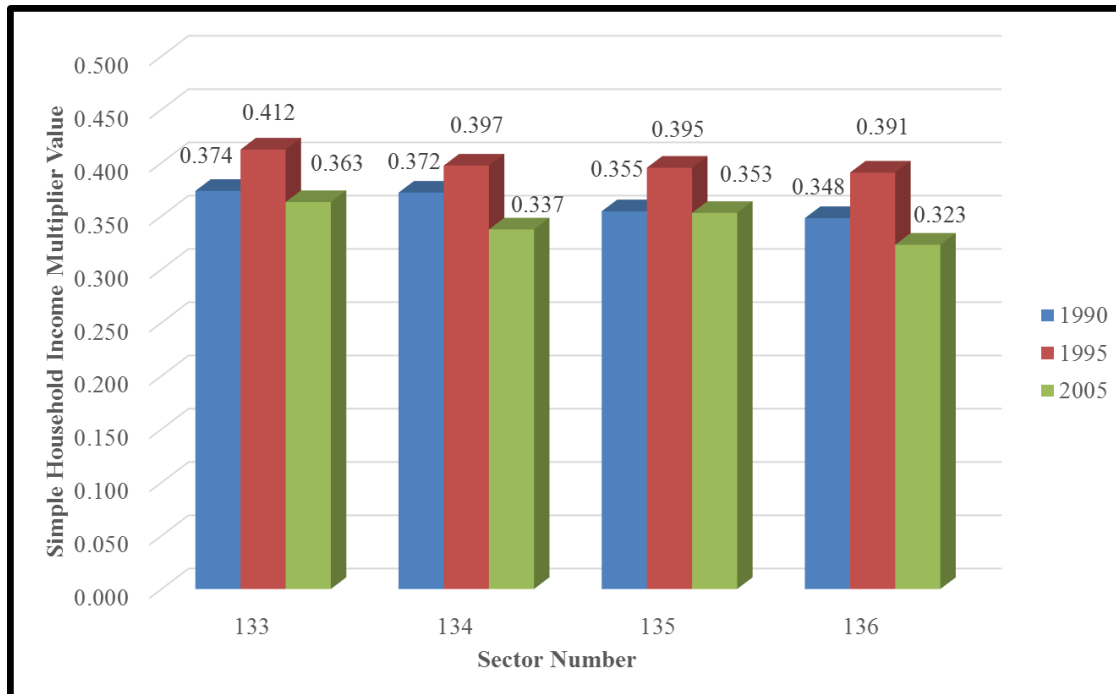


Figure 2. The Simple Household Income Multiplier Values of Analyzed Industries, 1990-2005

Table 8 summarizes the quadrants of analyzed industries on the analysis period. 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. The combination itself generates four quadrants.

Each quadrant has characteristics. More specifically, the quadrant I is a location where the values of both indices are more than one. In other words, the industries include on this quadrant are those most affected by the external aspects as well as have strong influences on the entire industries. The opposite phenomena can be viewed on the sectors which include on the quadrant III. On the other hand, quadrant II is a place where the value of the index of the power of dispersion is less than one while the value of another index is more than one. One can say that the industries include on this quadrant are those which have weak impacts on the entire industries, but they get high influences from the changes of external aspects. The opposite characteristics are owned by the industries which include on the quadrant IV.

Table 8. The Quadrants of Indonesian Construction Sectors, 1990-2005

Sector Number	Sector Name	Quadrant		
		1990	1995	2005
133	Construction on agriculture	IV	III	IV
134	Public work on road, bridge and harbor	IV	IV	IV
135	Construction and installation on electricity, gas, water supply and communication	IV	IV	IV
136	Other construction	IV	IV	IV

Based on the information in the table, on the analysis period, one can say that the analyzed sectors almost always occupied the quadrant IV. An exception could be seen on the construction on agriculture sector in 1995. These facts



explain that the majority of analyzed industries had strong impacts on the entire industries, but they got low influences from the changes of external aspects on the period of analysis.

#### 4. Conclusions and Further Researches

This study analyzes the roles of Indonesian construction industries in the Indonesian national economy by using IO analysis. More specifically, this study uses simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis tools. The analysis period of this study is 1990-2005. The analyzed Indonesian construction sectors in this study are (1) construction on agriculture, (2) public work on road, bridge and harbor, (3) construction and installation on electricity, gas, water supply and communication, and (4) other construction.

The results show that, by using both multipliers, the analyzed construction industries did not include in the top five Indonesian industrial sectors from 1990 through 2005. By using both indices, the analyzed sectors almost always occupied the quadrant IV on the period of analysis. An exception could be observed on the sector number 133, construction on agriculture, in 1995. These facts show that the majority of analyzed industries had strong effects on the entire industrial sectors, but they got low impacts from the changes of external aspects on the analysis period.

The understanding regarding the roles of Indonesian construction sectors in impacting the Indonesian national economy on the period of analysis is obtained from the current study. However, the study would gain a broader insight about the roles if the study could use the longer analysis period. Therefore, as a further research, the study proposes the same analysis by utilizing the longer period of analysis, such as from 1990 through 2015. One of the important points in conducting this further research 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 do an international comparison using the same methods. The comparison can be conducted among developed as well as developed-developing nations. The comparison might explore the roles of the construction sectors of compared countries so the similarities and differences among those regarding the industries can be analyzed. One of the examples of this further research is the comparison between Indonesia and Japan.

#### Acknowledgements

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#### Appendix

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

Sector Number	Sector Name
1	Paddy
2	Maize
3	Cassava
4	Other root crops include sweet potatoes
5	Groundnut
6	Soybeans
7	Other beans
8	Vegetables
9	Fruits
10	Cereals and other food crops
11	Rubber
12	Sugarcane
13	Coconut

14	Oil palm
15	Fibre crops
16	Tobacco
17	Coffee
18	Tea
19	Clove
20	Other estate crops
21	Other agriculture
22	Livestock and livestock product except fresh milk
23	Fresh milk
24	Poultry and its product
25	Other livestock raising
26	Wood
27	Other forest product
28	Sea fish and other sea products
29	Inland water fish and its product
30	Coal
31	Crude oil
32	Natural gas and geothermal
33	Tin ore
34	Nickel ore
35	Bauxite ore
36	Copper ore
37	Gold and silver ore
38	Other mining
39	Crude salt
40	Quarrying, all kinds
41	Meat and entrails of slaughtered animal
42	Processed and preserved meat
43	Dairy products
44	Canning and preserving of fruits and vegetables
45	Drying and salting of fish
46	Processed and preserved fish
47	Copra, animal oil and vegetables oil
48	Rice
49	Wheat flour
50	Other flour
51	Bakery product and the like
52	Noodle, macaroni and the like
53	Sugar
54	Peeled grain, chocolate and sugar confectionery
55	Milled and peeled coffee
56	Processed tea

57	Soya bean products
58	Other foods
59	Animal feeds
60	Alcoholic beverages
61	Non-alcoholic beverages
62	Tobacco products
63	Cigarettes
64	Yarn and cleaning kapok
65	Textile
66	Made up textile goods except wearing apparel
67	Knitting mills
68	Wearing apparel
69	Manufacture of carpet, rope, twine and other textile
70	Leather tanneries and leather finishing
71	Manufacture of footwear and leather products
72	Sawmill and preserved wood
73	Manufacture of plywood and the like
74	Wooden building components
75	Manufacture of furniture and fixtures mainly made of wood, bamboo and rattan
76	Manufacture of other products mainly made of wood, bamboo, rattan and cork
77	Manufacture of non-plastic plait
78	Pulp
79	Paper and cardboard
80	Paper and cardboard products
81	Printing and publishing
82	Basic chemical except fertilizer
83	Fertilizer
84	Pesticides
85	Synthetic resins, plastic and fibre
86	Paints, varnishes and lacquers
87	Drugs and medicine
88	Native medicine
89	Soap and cleaning preparation
90	Cosmetics
91	Other chemical products
92	Petroleum refineries products
93	Liquefied of natural gas
94	Smoked and crumb rubber
95	Tire
96	Other rubber products
97	Plastic products

98	Ceramic and earthenware
99	Glass products
100	Clay and ceramic structural products
101	Cement
102	Other non-ferrous products
103	Basic iron and steel
104	Basic iron and steel products
105	Non-ferrous basic metal
106	Non-ferrous basic metal products
107	Kitchen wares, hand tools and agricultural tools
108	Furniture and fixed primarily made of metal
109	Structural metal products
110	Other metal products
111	Prime movers engine
112	Machinery and apparatus
113	Electric generator and electrical motor
114	Electrical machinery and apparatus
115	Communication, electronical equipment and apparatus
116	Household electronics appliances
117	Other electrical appliances
118	Battery and storage battery
119	Ship and its repair
120	Train and its repair
121	Motor vehicle except motorcycle
122	Motorcycle
123	Other transport equipment
124	Aircraft and its repair
125	Measuring, photographic and optical equipment
126	Jewelry
127	Musicals instruments
128	Sporting and athletics goods
129	Other manufacturing industries
130	Electricity and gas
131	Water supply
132	Residential and non-residential buildings
133	Construction on agriculture
134	Public work on road, bridge and harbor
135	Construction and installation on electricity, gas, water supply and communication
136	Other construction
137	Trade
138	Restaurant
139	Hotel

140	Railway transport
141	Road transport
142	Sea transport
143	River and lake transport
144	Air transport
145	Services allied to transport
146	Communication services
147	Banking and other financial intermediaries
148	Insurance and pension fund
149	Building and land rent
150	Business services
151	General government
152	Education services
153	Health services
154	Other community services
155	Private motion picture and its distribution
156	Amusement, recreational and cultural services (private)
157	Repair shop n.e.c
158	Personal and household services
159	Other goods and services n.e.c

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## Biographies

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