



**UNIVERSITI PUTRA MALAYSIA**

**RELATIVE IMPROVEMENTS IN ROAD MOBILITY COMPARED TO  
IMPROVEMENTS IN ROAD ACCESSIBILITY, URBANIZATION AND  
ECONOMIC GROWTH**

**NG CHOY PENG**

**FK 2019 68**



**RELATIVE IMPROVEMENTS IN ROAD MOBILITY COMPARED TO  
IMPROVEMENTS IN ROAD ACCESSIBILITY, URBANIZATION AND  
ECONOMIC GROWTH**

By

**NG CHOY PENG**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfillment of the Requirements for the Degree of Doctor of Philosophy**

**December 2018**

## **COPYRIGHT**

All material contained within the thesis, including without limitation text, logos, icons, photographs, and all other artwork, is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia.

Copyright © Universiti Putra Malaysia



## DEDICATIONS

My family and friends are the most important things in my life. I would not have been able to complete this study without the support, encouragement, inspiration and motivation of my beloved family and friends.

I would like to dedicate this thesis to my beloved family and friends and to the memory of my father, who has since passed on in December 2017 and was unable to share the joy with me.



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

**RELATIVE IMPROVEMENTS IN ROAD MOBILITY COMPARED TO IMPROVEMENTS IN ROAD ACCESSIBILITY, URBANIZATION AND ECONOMIC GROWTH**

By

**NG CHOY PENG**

**December 2018**

**Chairman : Law Teik Hua, PhD**  
**Faculty : Engineering**

Roads can be classified according to their level of mobility and accessibility. Roads with higher mobility (i.e. motorways) provide limited access but largely uninterrupted travel with high speeds, thus improving travel time reliability for transporting people and goods. Roads with higher accessibility (i.e. local roads) provide limited mobility but offer more direct routes to specific destinations, generating potential for human interactions and opportunity for socioeconomic activities. Empirical studies indicated that an increase in road length contributed positively to socioeconomic growth. However, an important missing information from previous studies remain in the literatures, which is, what type of roads (either high mobility or high accessibility roads) are needed during different level of country's development?

In order to evaluate the performance of different road types during different level of country's development, the relative improvements in road mobility compared to improvements in road accessibility (MPA) was computed to evaluate the relationship between MPA and country's development and the presence of trend changes. Three empirical investigations were conducted and the research objectives are as follows: (1) to evaluate how MPA facilitates export-led growth processes and to determine the investment level needed for different road types to facilitate economic and commercial activities at different developmental levels, (2) to determine the investment level required for different road types in order to facilitate urbanization at different levels of urbanization and to comprehend how the development of MPA promotes export-led urban growth and (3) to assess the indirect effect of MPA on economic growth transmitted through the impacts of MPA on urbanization and exports. To shed light on the above issues, fixed-effects panel linear regression analysis was conducted using time-series cross-sectional data on the MPA and growth data for 60 countries over the period of 31 years, from 1980 to 2010.

This first empirical study divided the countries into three groups: (1) countries with a high level of development, (2) countries with a medium level of development and (3) countries with a low level of development. The key finding of this study was that a greater relative improvement in MPA would facilitate export-led growth in countries with a high and medium level of development. This indicates that policy to promote export and high mobility road network expansion should be carried out hand-in-hand to enhance economic growth. This is specifically true for countries with a medium level of development, as these countries generally suffer from lower levels of high mobility road network development. Such expansion in road mobility is necessary to fulfil demands for long-distance travel and enable the transportation of people and goods across regions, thereby facilitating productivity and trade. On the other hand, in countries with a low level of development, more investment is required to build roads with high accessibility. Such road are needed to facilitate local business and trade activities. This is crucial in order to achieve a sustainable economic growth.

The second empirical study examine the effect of MPA on urbanization. The evidence presented in this study suggests that improvements in road mobility promoted export-led urban growth in countries with a low level of urbanization. This implies that policies to facilitate export should be executed in conjunction with high mobility road network expansion to increase urbanization, especially in countries with a low level of urbanization that commonly suffer from low growth rates and that have a low level of high mobility road networks. Such expansion in road mobility is required to fulfil demands for long-distance travel to transport people from rural to urban areas. In contrast, in countries with a high level of urbanization, more investment is needed to develop roads with high accessibility. Such roads are needed to fulfil daily travel demands as a consequence of urban sprawl and decentralization of employment and populations. Moreover, the evidence shows that per capita education level and physical capital stock per worker contributed to urbanization.

The third empirical study examine the indirect effects MPA on economic growth, transmitted through the effects of MPA on urbanization and exports. The total effects of MPA on economic growth is computed by adding the two indirect effects. The indirect effects of MPA on economic growth were estimated based on the prediction of three different panel models: the first model relates per capita gross domestic product (GDP) with urbanization and exports, the second model associates urbanization with the MPA and the third model links exports with the MPA. The estimated results imply that the growth in MPA appeared to be associated with a rise in per capita GDP at lower level of urbanization and export but associated with a decline in per capita GDP at higher level of urbanization and export. On the other hand, for the indirect effect of MPA on per capita GDP via urbanization, the level of MPA that maximizes per capita GDP decreases with increases in the levels of physical capital stock per worker and per capita education level. For the computation of total effect, the level of MPA that maximizes per capita GDP is ranged between 0.0485 and 0.5860. In summary, this study suggest that policies focused on improving MPA should be implemented hand-in hand with other socioeconomic and urbanization policies, in order to realize a sustainable economic growth.

As evidenced by empirical studies conducted in this research, high mobility road network growth alone is not sufficient to put urbanization and economy on a sustainable growth path. Although improvements in road mobility are crucial in countries with a high and medium level of development, improved road accessibility has a greater influence on export growth in countries with a low level of development. The latter can be explained as follows: at lower development levels, populations are more concentrated in smaller areas, and business activities mainly occur at the local scale. Moreover, the findings also revealed that high road accessibility has a more important impact on export growth at a high level of urbanization to support daily travel needs as a result of urban sprawl and the decentralization of employment and population.

The empirical evidence indicates that the effect of relative improvements in road mobility was ambiguous, with both positive and negative effects on economic growth observed. Relative improvements in road mobility appear to be accompanied by an increase in per capita GDP at lower levels of urbanization and exports but accompanied by a decrease in per capita GDP at higher levels of urbanization and exports. Therefore, to attain sustainable economic growth, road infrastructure development policies should be implemented alongside exports and urbanization policies.

In this research, most of the countries with a low level of development in the sample also had a low level of urbanization. The evidence indicates that in countries with a low level of development, improvements in high accessibility road network promote local business and trade activities. Furthermore, in countries with a low level of urbanization, improvements in high mobility road network facilitate migration from rural to urban areas. Therefore, achieving a balance road infrastructure development between both high mobility and high accessibility road network is crucial to attain sustainable economic and urbanization in countries with a low level of urbanization.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PENINGKATAN RELATIF DARI SEGI MOBILITI JALAN BERBANDING  
DENGAN PENINGKATAN DARI SEGI AKSESIBILITI JALAN,  
URBANISASI DAN PERTUMBUHAN EKONOMI**

Oleh

**NG CHOY PENG**

**Disember 2018**

**Pengerusi : Law Teik Hua, PhD**  
**Fakulti : Kejuruteraan**

Jalan raya boleh dikelaskan mengikut aras mobiliti dan aksesibiliti. Jalan raya beraras tinggi dari segi mobiliti (contohnya lebuh raya) menyediakan akses jalan yang amat terhad tetapi perjalanan yang tidak terganggu dan berkelajuan tinggi, justeru itu, dapat meningkatkan kebolehpercayaan dari segi masa perjalanan untuk penghantaran manusia dan barangan. Jalan raya beraras tinggi dari segi aksesibiliti (contohnya jalan tempatan) memberikan mobiliti yang amat terhad tetapi menawarkan laluan terus ke destinasi khusus, justeru itu, berpotensi untuk menjana interaksi di antara manusia dan peluang untuk pelbagai aktiviti sosioekonomi. Kajian empirikal menunjukkan bahawa peningkatan dari segi panjang jalan dapat menyumbang secara positif kepada pertumbuhan sosioekonomi. Walau bagaimanapun, satu maklumat penting yang tertinggal dalam kajian terdahulu, iaitu, apakah jenis jalan (sama ada jalan beraras tinggi dari segi mobiliti atau jalan beraras tinggi dari segi aksesibiliti) yang diperlukan pada peringkat pembangunan negara yang berbeza?

Untuk menilai prestasi jenis jalan yang diperlukan pada peringkat pembangunan negara yang berbeza, peningkatan relatif dari segi mobiliti jalan berbanding dengan peningkatan dari segi aksesibiliti jalan (MPA) telah diterbitkan untuk menilai hubungan di antara MPA pada peringkat pembangunan negara yang berbeza dan apabila terdapat perubahan trend. Tiga kajian empirikal telah dilaksanakan dan objektif penyelidikan adalah seperti berikut: (1) untuk menilai bagaimanakah MPA memudahkan proses pertumbuhan eksport yang diterajui dan menentukan tahap pelaburan yang diperlukan untuk jenis jalan bagi memudahkan aktiviti ekonomi dan komersil pada peringkat pembangunan negara yang berbeza, (2) untuk menentukan tahap pelaburan yang diperlukan untuk jenis jalan bagi memudahkan pertumbuhan bandar pada peringkat urbanisasi yang berbeza dan untuk memahami bagaimana pembangunan MPA dapat menggalakkan pertumbuhan bandar yang diterajui eksport



dan (3) untuk menilai kesan sampingan MPA terhadap pertumbuhan ekonomi di mana kesan MPA tersebut disalurkan terdahulu kepada urbanisasi dan eksport. Untuk memberi penerangan lanjut mengenai isu-isu di atas, analisis regresi linear panel berkesan tetap telah dilaksanakan dengan menggunakan MPA dan data pertumbuhan rentetan siri masa untuk 60 negara dalam tempoh 31 tahun, dari 1980 hingga 2010.

Kajian empirikal yang pertama membahagikan negara-negara kepada tiga kumpulan: (1) negara-negara pada peringkat pembangunan tinggi, (2) negara-negara pada peringkat pembangunan sederhana dan (3) negara-negara pada peringkat pembangunan rendah. Penemuan utama kajian ini menunjukkan bahawa peningkatan lebih tinggi dalam MPA akan memudahkan pertumbuhan eksport yang diterajui di negara-negara pada peringkat pembangunan tinggi dan sederhana. Ini mecadangkan bahawa dasar untuk menggalakkan eksport dan pengembangan rangkaian jalan raya beraras tinggi dari segi mobiliti harus dilakukan secara bersemuka untuk meningkatkan pertumbuhan ekonomi. Ini adalah penting terutamanya untuk negara-negara dalam peringkat pembangunan sederhana kerana negara-negara ini secara umumnya mengalami tahap pembangunan rangkaian jalan raya beraras tinggi dari segi mobiliti yang lebih rendah. Pengembangan rangkaian jalan raya sedemikian dapat memenuhi permintaan untuk perjalanan jarak jauh dan membolehkan pengangkutan manusia dan barangan di seluruh rantau dan juga meningkatkan produktiviti dan memudahkan perdagangan. Sebaliknya, untuk negara-negara pada peringkat pembangunan rendah, lebih banyak pelaburan diperlukan untuk membina rangkaian jalan raya beraras tinggi dari segi aksesibiliti. Jalan raya sedemikian diperlukan untuk memudahkan aktiviti perniagaan dan perdagangan tempatan. Ini adalah penting untuk mencapai pertumbuhan ekonomi yang mampan.

Kajian empirikal kedua mengkaji kesan MPA terhadap pertumbuhan bandar. Bukti yang dibentangkan dalam kajian ini menunjukkan bahawa pembangunan rangkaian jalan raya beraras tinggi dari segi mobiliti mempromosikan pertumbuhan bandar yang menerajui eksport di negara-negara pada peringkat urbanisasi yang rendah. Ini menunjukkan bahawa dasar eksport perlu dilakukan bersama dengan dasar pengembangan rangkaian jalan raya beraras tinggi dari segi mobiliti bagi meningkatkan proses perbandaran, khususnya di negara-negara yang mempunyai tahap urbanisasi rendah yang lazimnya mengalami kadar pertumbuhan rendah yang juga mempunyai rangkaian jalan raya beraras tinggi dari segi mobiliti yang rendah. Peluasan rangkaian jalan raya sedemikian diperlukan untuk memenuhi permintaan perjalanan jarak jauh untuk penghijrahan penduduk dari kawasan luar bandar ke bandar. Sebaliknya, di negara-negara pada peringkat urbanisasi yang tinggi, lebih banyak pelaburan diperlukan untuk membangunkan rangkaian jalan raya beraras tinggi dari segi aksesibiliti. Jalan raya sedemikian diperlukan untuk memenuhi permintaan perjalanan harian berikutan dengan perluasan kawasan bandar ke zon pinggir dan desentralisasi pekerjaan dan penduduk. Selain itu, turut dibuktikan bahawa peringkat pendidikan per kapita dan stok modal fizikal bagi pekerja menyumbang terhadap pertumbuhan bandar.

Kajian empirikal ketiga mengkaji kesan tidak langsung MPA terhadap pertumbuhan ekonomi, yang ditransmisikan melalui kesan MPA ke atas urbanisasi dan eksport. Kesan keseluruhan MPA terhadap pertumbuhan ekonomi diambilkira dengan menambahkan kedua-dua kesan secara tidak langsung. Kesan secara tidak langsung MPA terhadap pertumbuhan ekonomi dianggarkan berdasarkan ramalan tiga model panel yang berbeza: model pertama mengaitkan keluaran dalam negara kasar (KDNK) per kapita dengan pertumbuhan bandar dan eksport, model kedua mengaitkan urbanisasi dengan MPA dan model ketiga mengaitkan eksport dengan MPA. Keputusan yang dianggarkan menunjukkan bahawa peningkatan MPA adalah berkaitan dengan pertumbuhan KDNK per kapita pada tahap urbanisasi dan eksport yang lebih rendah tetapi berkurangan dengan penurunan KDNK per kapita pada tahap urbanisasi dan eksport yang lebih tinggi. Selain itu, untuk kesan tidak langsung MPA terhadap KDNK per kapita yang ditransmisikan melalui urbanisasi, tahap MPA yang memaksimumkan KDNK per kapita berkurangan berikutan dengan peningkatan stok modal fizikal bagi pekerja dan peringkat pendidikan per kapita. Untuk pengiraan jumlah kesan, tahap MPA yang memaksimumkan KDNK per kapita adalah di antara 0.0485 dan 0.5860. Secara ringkasnya, kajian ini mencadangkan bahawa dasar-dasar yang menumpu pada peningkatan MPA harus dilaksanakan bersama-sama dengan dasar pertumbuhan sosioekonomi dan urbanisasi bagi mewujudkan pertumbuhan ekonomi yang mampan.

Seperti yang dibuktikan oleh analisis dalam penyelidikan ini, pertumbuhan rangkaian jalan raya beraras tinggi dari segi mobiliti sahaja tidak mencukupi untuk mewujudkan urbanisasi dan pertumbuhan ekonomi yang mampan. Walaupun peningkatan rangkaian jalan raya beraras tinggi dari segi mobiliti adalah penting di negara-negara pada peringkat pembangunan tinggi dan sederhana, pertumbuhan rangkaian jalan raya beraras tinggi dari segi aksesibiliti mempunyai pengaruh yang lebih besar terhadap pertumbuhan eksport di negara-negara pada peringkat pembangunan rendah. Ini boleh dijelaskan seperti berikut: pada peringkat pembangunan rendah, penduduk adalah tertumpu di kawasan kecil dan aktiviti perniagaan berlaku pada skala tempatan. Tambahan pula, rangkaian jalan raya beraras tinggi dari segi aksesibiliti mempunyai impak yang lebih penting terhadap pertumbuhan eksport pada peringkat urbanisasi yang tinggi untuk menyokong keperluan perjalanan harian berikutan dengan perluasan kawasan bandar ke zon pinggir dan desentralisasi pekerjaan dan penduduk.

Bukti dari penyelidikan ini juga menunjukkan bahawa kesan peningkatan secara relatif dari segi mobiliti jalan adalah amat mengelirukan kerana wujudnya kesan positif dan negatif terhadap pertumbuhan ekonomi. Peningkatan relatif dari segi mobiliti jalan kelihatan disertai dengan peningkatan KDNK per kapita pada tahap urbanisasi dan eksport yang lebih rendah tetapi disertai dengan penurunan KDNK per kapita pada peringkat urbanisasi dan eksport bandar yang lebih tinggi. Oleh itu, untuk mencapai pertumbuhan ekonomi yang mampan, dasar pembangunan infrastruktur jalan perlu dilaksanakan bersama dengan dasar eksport dan dasar urbanisasi.

Dalam kajian ini, turut diperhatikan bahawa kebanyakan negara yang berada pada peringkat pembangunan rendah juga mempunyai tahap urbanisasi yang rendah. Bukti yang dikemukakan menunjukkan bahawa negara-negara pada peringkat pembangunan rendah memerlukan penambahbaikan untuk rangkaian jalan raya beraras tinggi dari segi aksesibiliti untuk mempromosikan aktiviti perniagaan dan perdagangan tempatan. Di samping itu, bagi negara-negara yang mempunyai tahap urbanisasi rendah, penambahbaikan rangkaian jalan raya beraras tinggi dari segi mobiliti memudahkan penghijrahan penduduk dari kawasan luar bandar ke bandar. Justeru itu, untuk mencapai pertumbuhan ekonomi mampan dan kelestarian bandar di negara-negara yang mempunyai tahap urbanisasi yang rendah, pembangunan rangkaian jalan raya beraras tinggi dari segi mobiliti dan aksesibiliti perlu diseimbangkan.



## ACKNOWLEDGEMENTS

I have benefited greatly from the guidance, assistance, advice, inspiration and support of many people over the period of my study.

First and foremost, I would like to express my gratitude to my supervisor, Assoc. Prof. Dr. Law Teik Hua, who instilled on me the importance of conducting meaningful research and thinking critically and thoroughly about my research. I appreciate his vast knowledge and skills in many areas, especially spending countless hours with me for discussions and providing excellent comments and suggestions throughout the course of my research. His expertise, understanding, and patience, added considerably to my graduate experience.

I would also like to thank the other members and ex-member of my thesis supervisory committee, Dr. Fauzan Mohd. Jakarni, Associate Prof. Dr. Kulanthayan K.C. Mani @ Subramaniam and Prof. Dr. Wong Shaw Voon for the assistance and support they provided at all levels of my study in Universiti Putra Malaysia.

My gratitude also goes to the staff, members, students and ex-students of Road Safety Research Centre for their support and company over all these years – Dr. Tan Kean Sheng, Dr. Alfian Abdul Halin, Dr. Nur Sabahiah Abdul Sukor, Norfaizah, May Yen, Muzamir, Alvin, Aini, Hana, Syazwan, Kavi, Kavitha, Mashid, Rashid and Hii.

Special appreciation also goes to my colleagues and ex-colleagues, especially my Head of Department, for their understanding and support throughout my study period – Assoc. Prof. Dr. Aniza Ibrahim, Assoc. Prof. Mohd. Asri Md. Nor, En. Muhamad Azani Yahya, En. Zulkifli Abu Hassan, Assoc. Prof. Dr. Mohamad Alias Yusof, Capt. (R) Neza Ismail, Col. Prof. Ir. Dr. Norazman Mohamad Nor, En. Ahmad Shahrir, Prof. Megat Mohamad Hamdan Megat Ahmad, Prof. Faisal Hj. Ali, Hanim, Jestin, Hapsa, Zuliziana, Dila, Maidiana, Suriyadi, Mej. Vikneswaran, Nazrin, Siti, Aina and Syafuan.

I wish to sincerely thank my friends and buddies who are always there to listen and to give motivation and moral support to me – Connie, Ms. Soong, Yee Heng, York Meng, Daisy, Hoo, Sue Ping, Ai Ping, Seng Coon, Mun Fei, Xzee Ling, Sim Yee, Yen Ling, Joceline, Aunt Young and Pathma.

Last but not least, I want to thank my beloved family members especially my mother, my husband and my son for their love, patience, sacrifice, encouragement, spiritual and emotional support through prayers.

Any omission in this brief acknowledgement does not mean lack of gratitude. I sincerely thank everyone who have provided a helping hand to me directly or indirectly throughout my study period.

A million thanks to all!



This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

**Law Teik Hua, PhD**

Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Fauzan Mohd. Jakarni, PhD**

Senior Lecturer  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

**Kulanthayan K.C. Mani, PhD**

Associate Professor  
Faculty of Medicine and Health Science  
Universiti Putra Malaysia  
(Member)

---

**ROBIAH BINTI YUNUS, PhD**

Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:

## Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Name and Matric No.: Ng Choy Peng, GS30097



## TABLE OF CONTENTS

	<b>Page</b>
<b>ABSTRACT</b>	i
<b>ABSTRAK</b>	iv
<b>ACKNOWLEDGEMENTS</b>	vi
<b>APPROVAL</b>	x
<b>DECLARATION</b>	xii
<b>LIST OF TABLES</b>	xvii
<b>LIST OF FIGURES</b>	xix
<b>LIST OF ABBREVIATIONS</b>	xxi
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Introduction	1
1.2 Background of the Study	2
1.3 Research Problem	4
1.4 Objectives of the Study	5
1.5 Significance of the Study	5
1.6 Scopes of the Study	6
1.7 Outline of the Dissertation	7
<b>2 LITERATURE REVIEW</b>	<b>9</b>
2.1 Different Types of Road Classification	9
2.1.1 Important Concepts and Terms	9
2.1.2 Concept of Mobility and Accessibility	10
2.2 Global Development Trend of Road Infrastructure	11
2.2.1 The Development of Motorway Networks	20
2.2.2 The Development of Highways, Main or National Road Networks	28
2.2.3 The Development of Secondary or Regional Road Networks	32
2.2.4 The Development of Other Road Networks	34
2.2.5 The Role of World Bank in Road Infrastructure Development	35
2.2.6 The Role of Other Agencies in Road Infrastructure Development	37
2.3 Empirical Studies on Road Infrastructure Development and Economic Growth	39
2.3.1 Agglomeration Economics	39
2.3.2 Road Infrastructure Development and Economic Growth Nexus	39
2.3.3 Cross-Country Comparisons	43
2.3.4 Summary and Gap of Research	44
2.4 Empirical Studies on Road Infrastructure Development and Export	45
2.4.1 Export-Led Growth	45



2.4.2	Road Infrastructure Development and Export-Led Growth Nexus	47
2.4.3	Summary and Gap of Research	50
2.5	Empirical Studies on Road Infrastructure Development and Urbanization	50
2.5.1	Urbanization and Urban Sprawl	50
2.5.2	Road Infrastructure Development, Exports and Urbanization Growth Nexus	51
2.5.3	Summary and Gap of Research	54
2.6	The Direct and Indirect Effects of Road Infrastructure Development, Urbanization, Exports and Economic Growth Nexus	54
2.7	Summary	56
<b>3</b>	<b>METHODOLOGY</b>	<b>57</b>
3.1	Introduction	57
3.2	The Study Design	57
3.2.1	Literature Review	58
3.2.2	Identification of Research Gap and Framing of Research Objectives	58
3.2.3	Designing Framework to Achieve Research Objectives	58
3.2.3.1	Research Objective 1	58
3.2.3.2	Research Objective 2	59
3.2.3.3	Research Objective 3	59
3.2.4	Identification of Research Methodology	60
3.2.5	Data Collection, Data Analysis and Interpretation	60
3.2.6	Collation of Findings, Conclusions, Contributions, Limitations and Future Scope of Works	61
3.3	Theoretical Framework	61
3.3.1	Neoclassical Growth Theory	61
3.3.2	Endogenous Growth Theory	62
3.4	Framework and Model for Estimating The Nexus Between Road Infrastructure Development, Urbanization and Economic Growth	62
3.4.1	Framework and Model for Empirical Study 1	63
3.4.2	Framework and Model for Empirical Study 2	64
3.4.3	Framework and Model for Empirical Study 3	64
3.5	Data Sources and Variable Descriptions	65
3.5.1	Data Sources	65
3.5.2	Variable Descriptions	66
3.6	Data Analysis Method	69
3.6.1	Descriptive Statistics	69
3.6.2	Pearson Correlation Analysis	70
3.6.3	Panel Linear Regression	70
3.6.4	Fixed-Effects and Random-Effects Models	71
3.6.5	Hausman Test	72
3.6.6	Multicollinearity Problem	72
3.7	Methodology for Empirical Study 1	73
3.7.1	Data Sources and Variables	73

3.7.2	Estimation Methodology	75
3.8	Methodology for Empirical Study 2	75
3.8.1	Data Sources and Variables	75
3.8.2	Estimation Methodology	77
3.9	Methodology for Empirical Study 3	78
3.9.1	Data Sources and Variables	78
3.9.2	Theoretical Model and Mechanisms for Indirect Effect Estimation	79
3.10	Summary	80
<b>4</b>	<b>RESULTS AND DISCUSSIONS</b>	<b>81</b>
4.1	Introduction	81
4.2	Empirical Study 1	81
4.2.1	Results and Discussions	81
4.2.2	Summary	86
4.3	Empirical Study 2	87
4.3.1	Results and Discussions	87
4.3.2	Summary	90
4.4	Empirical Study 3	91
4.4.1	Results and Discussions	91
4.4.2	Model of Urbanization, Exports and Economic Growth	92
4.4.3	Model of MPA and Urbanization	93
4.4.4	Model of MPA and Exports	93
4.4.5	Estimation of the Indirect Effects of MPA	94
4.4.6	Summary	97
<b>5</b>	<b>CONCLUSIONS AND RECOMMENDATION FOR FUTURE RESEARCH</b>	<b>99</b>
5.1	Summary of the Main Empirical Findings	99
5.2	Research Contribution	100
5.3	Policy Implications	101
5.4	Limitations of the Analyses	102
5.5	Directions for Further Research	103
	<b>REFERENCES</b>	<b>105</b>
	<b>BIODATA OF STUDENT</b>	<b>123</b>
	<b>LIST OF PUBLICATIONS</b>	<b>124</b>

## LIST OF TABLES

<b>Table</b>	<b>Page</b>
2.1 Total road networks for 70 countries in 1980	13
2.2 Total road networks for 92 countries in 2010	16
2.3 Comparison of motorway network length for 32 Countries	25
2.4 Comparison of the increased in the length of highways, main or national road network for 35 countries	29
2.5 Comparison of the reduction in the length of highways, main or national road network for 20 countries	30
2.6 Completed National Highway projects in China financed by World Bank	36
2.7 Completed road projects financed by World Bank	36
2.8 Completed road infrastructure development projects financed by ADB (1983-2010)	38
3.1 Description of data and variables source	66
3.2 List of countries and the available years of data	73
3.3 List of countries and the available years of data	76
3.4 List of countries and the available years of data	78
4.1 Descriptive statistics for all countries	82
4.2 Descriptive statistics for countries with $HDI \geq 0.85$	82
4.3 Descriptive statistics for countries with $0.65 \leq HDI < 0.85$	82
4.4 Descriptive statistics for countries with $HDI < 0.65$	82
4.5 Correlation matrix	83
4.6 Estimates of economic growth	84
4.7 Estimates of economic growth in the case of different country type	86
4.8 Descriptive statistics for all countries	87
4.9 Descriptive statistics at low level of urbanization ( $Urb < 2.5$ )	87

4.10	Descriptive statistics at high level of urbanization ( $Urb \geq 2.5$ )	88
4.11	Correlation matrix	88
4.12	Estimates of urbanization	89
4.13	Estimates of urbanization in the case of different urbanization level	90
4.14	Descriptive statistics for all variables used in equations 3.16, 3.17 and 3.18	91
4.15	Correlation matrix for equations 3.16, 3.17 and 3.18	92
4.16	Estimates of economic growth	92
4.17	Estimates of urbanization	93
4.18	Estimates of exports	94

## LIST OF FIGURES

Figure	Page
1.1 Relationship between road infrastructure development, urbanization and economic growth	1
1.2 Formulation of MPA to measure the effect of different road types needed during different levels of country's development	5
2.1 Relationship of functionally classified systems in serving traffic mobility and land access for roads in IRF	11
2.2 Motorway	20
2.3 Countries with motorway network in 1980 (10 – 100 km)	21
2.4 Countries with motorway network in 1980 (100 – 450 km)	21
2.5 Countries with motorway network in 1980 (500 – 6,000 km)	22
2.6 Countries with motorway network in 2010 (15 – 400 km)	23
2.7 Countries with motorway network in 2010 (400 – 900 km)	23
2.8 Countries with motorway network in 2010 (1,000 – 2,500 km)	24
2.9 Countries with motorway network in 2010 (2,500 – 20,000 km)	24
2.10 Comparison of motorway network for selected countries (1980 – 2010)	26
2.11 Ratio of motorway to total road network length in 1980	27
2.12 Ratio of motorway to total road network length in 2010	27
2.13 Ratio of highways, main or national road network to total road network length in 1980	31
2.14 Ratio of highways, main or national road network to total road network length in 2010	31
2.15 Ratio of secondary or regional road network to total road network length in 1980	33
2.16 Ratio of secondary or regional road network to total road network length in 2010	33
2.17 Ratio of other road network to total road network length in 1980	34
2.18 Ratio of other road network to total road network length in 2010	35

3.1	Flow chart of the research methodology	57
3.2	The indirect effects of road infrastructure development, exports, urbanization and economic growth	60
3.3	Framework for Empirical Study 1	63
3.4	Framework for Empirical Study 2	64
3.5	Framework for Empirical Research 3	65
4.1	Graph exports versus MPA	94
4.2	Graph per capita GDP versus exports	94
4.3	Graph urbanization versus MPA	95
4.4	Graph per capita GDP versus urbanization	95
4.5	The marginal effect of MPA on economic growth at the minimum level of per capita education level and physical capital stock per workers	96
4.6	The marginal effect of MPA on economic growth at the maximum level of per capita education level and physical capital stock per workers	96

## LIST OF ABBREVIATIONS

DV	Dependent variable
FE	Fixed-effects
GDP	Gross Domestic Product
GNP	Gross National Product
HDI	Human Development Index
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IEA	International Energy Agency
IRF	International Road Federation
IV	Independent variable
KDNK	Keluaran Dalam Negara Kasar
Max	Maximum
Min	Minimum
MPA	Relative improvements in road mobility compared to improvements in road accessibility
Obs.	Observation
OECD	Organisation for Economic Co-operation and Development
PWT 7.1	Penn World Table 7.1
RE	Random-effects
Std. Dev.	Standard deviation
UNDP	United Nations Development Programme
WB	World Bank
WBES	World Bank Education Statistics
WDI	World Development Indicator
WRS	World Road Statistics

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

The inter-linkages between road infrastructure development, urbanization and economic growth hold great importance for any country, especially developing countries and under developed countries. These three interrelated aspects are highly crucial in terms of the proper functioning of a country and that is why it becomes all the more important to analyse these inter-relationships.

A breadth of research (such as Friedlaender, 1965; Kuznets, 1966; Chenery and Taylor, 1968; Firebaugh, 1979; Preston, 1979; London, 1987; Brotchie, 1991; Krugman, 1991; Parker, 1995; Moomaw and Shatter, 1993; Moomaw and Shatter, 1996; Canning and Bennathan, 2000; Mitra, 2000; Priemus et al., 2001; Henderson, 2003; Gunasekera et al., 2008; Fan and Chan-Kang, 2008; Aljoufie et al, 2013a; Aljoufie et al, 2013b; Liu et al., 2014. ) has illustrated the interrelatedness of road infrastructure development, urbanization and economic growth. Figure 1.1 shows the relationship between the three factors.



**Figure 1.1 : Relationship between road infrastructure development, urbanization and economic growth**

The relationship in Figure 1.1 can be summarized as follow: an increase in agricultural surpluses and improvements in transportation, especially road infrastructure create an opportunity for trading and consequently the formation of new urban centres (Bairoch, 1998). Population agglomeration occurs in conjunction with the formation of new urban centres, which attract increased migration from rural to urban areas due to enhanced economic opportunity and other opportunities, such as education centre, health care services, credit facilities and etc. The development and expansion of road infrastructures reduce physical barriers to movement and stimulate the movements of people and goods, in addition to improving access to markets, social services and employment by decreasing the overall transportation times and costs. At the same time, the exogenous increase in agricultural productivity increases economic opportunities in urban centres by attracting investment and shifting labour from the agriculture



sector towards manufacturing industries (Gabardo et al., 2017) and secondary industries or non-agricultural industries (Marmara and Usman, 2015). Rapid economic growth in the city, such as in the export sectors also induced rural-urban migration. As the population increases in a city, the boundary of the city expands to accommodate growth, which leads to a greater demand for resources, such as food and commodities, as well as urban sprawl. As economic growth and urban sprawl occurs, the demand on road transport inevitably increases, contributed to the development of additional road infrastructure to support sustainable economic and urbanization.

## 1.2 Background of the Study

In general, roads can be classified according to their level of mobility and accessibility. Roads with higher mobility, such as motorways, provide limited access but largely uninterrupted travel at high speeds. The latter improves travel time reliability for transporting people, goods and services, increases the speed and volume of inter-regional migration and improves the efficiency of domestic and international trade. Roads with higher accessibility, such as local roads, provide limited mobility but offer more direct routes to specific destinations. Such roads generate potential for human interactions and opportunities for socioeconomic activities, such as material exchange (Saunders et al., 2002; Aljoefie et al., 2013a; Aljoufie et al., 2013b).

However, the level of road mobility and accessibility needed during the process of urbanization to sustain economic growth varies considerably at different developmental levels. On the demand side, at lower levels of development, the population is concentrated in smaller areas, and business activities mainly occur at the local scale. Therefore, there is more demand for short-distance travel for delivering goods and services. However, as the economy grows and the population expands, urban sprawl occurs, with residential and commercial facilities located in the suburbs. Increased numbers of people living in the suburbs contribute to automobile dependency and increases the need for more long-distance travel. On the supply side, at lower development levels, the scale of economic activity is small, limited and less varied in scope than at higher developmental levels. Therefore, more investment is needed in local roads at lower development levels as compared with that at higher development levels. At higher development levels, policy makers need to invest more resources to build high mobility roads, which are required to facilitate productivity and trade, thereby sustaining higher economic growth. Thus, in the presence of scarce resources, the decision to build roads with high mobility or high accessibility based on a country's development level may have a significant effect on urbanization and economic growth.

Economic theory suggests that the expansion of export-oriented industries leads to significant economic growth (Bernard and Jensen, 1999; Aw et al., 2000; Van Biesebroeck, 2006; De Loecker, 2007) because export growth can link local markets to international markets, which are almost limitless. Thus, there are no growth restrictions on the demand for goods (Helpman and Krugman, 1985; Lawrence et al., 1999; Esfahani, 1991; Easterly, 2007; Siliverstovs and Herzer, 2007). Economic

growth driven by export also contributes to the creation and dissemination of knowledge and skills, which consequently enhance the productive efficiency of manufacturing industries (Bhagwati, 1988). Thus, it is reasonable to say that export-led growth cannot be realized without adequate improvements in road infrastructure, including mobility and accessibility.

The urbanization and urban sprawl phenomenon becomes increasingly important as a result of globalisation of world economics. The benefits of urbanization and urban agglomeration, were first discussed in the Alonso-Mills-Muth model in a monocentric city (Alonso, 1964; Mills, 1967; Muth, 1969; Mills, 1972) that examines the effects of changes in given parameter structure of a city, and later on extended by Fujita and Ogawa (1982) to incorporate the impacts of additional urban sub-centres as well as urban sprawl. Notably, the Alonso-Mills-Muth model is very successful in demonstrating the urbanization and urban sprawl phenomenon where this model discusses the cost of transportation as city grow and expands geographically. The Alonso-Mills-Muth model also provides a simplified framework for describing urban activities and offers insight into urban spatial structures, travel behaviour and multiple location patterns, which is appropriate for urban-expansion analysis which models the trade-offs between accessibility, residents and employments in a monocentric urban formulation (Fujita, 1989).

Urban sprawl is a rapid expansion of the geographic extent of cities and towns. It is mainly caused in part by the need to accommodate a rising urban population in the city centre. As people live further away from the city centre, this has resulted in a reliance on the private vehicle for transportation and increased demand for additional road infrastructure. Urban sprawl has been correlated with increased energy use, pollution, as well as traffic congestion and a decline in community distinctiveness and cohesiveness. Likewise, further investment and improvement in road infrastructure support urban population growth, as well as urban sprawl and socioeconomic activities. According to Kuznets' theory of urbanization and economic growth, population migration from rural to urban areas is related to population growth and structural changes, which generate productivity and wage gains per worker and per capita GDP increases, with subsequent economic growth (Kuznets, 1966).

Urbanization is also closely related to development and improvements in quality of life. During the process of urbanization, road infrastructure plays a crucial role in development by enabling the efficient movement of people, who are involved in a wide variety of commercial and social activities, as well as goods and services (Meyer and Miller, 2001). Efficient road infrastructure or a good road network creates a competitive edge in cost efficient movement of goods. Conversely, the lack of road infrastructure or poor road network systems are barriers to agriculture, industry and trade and may hinder the process of urbanization and socioeconomic development. Therefore, road infrastructure plays a vital and integral role in socioeconomic development and the achievement of a sustainable society, in addition to urbanization and economic growth (Fernald, 1999; Canning and Bennathan, 2000; Saunders et al.,

2002; Pradhan 2007; Fan and Chan-Kang; 2008; Gunasekera et al., 2008; Aljoufie et al., 2013a; Aljoufie et al., 2013b; Zhang; 2013).

### 1.3 Research Problem

An in-depth literature review<sup>1</sup> has illustrated that, generally, the increase in road length, paved roads, highways and road density contributed substantially to urbanization and economic growth (Fernald, 1999; Hall and Pfeiffer, 2000; Hart, 2001; Liu et al., 2002; Crafts and Leunig, 2005; Handy, 2005; Xie et al., 2005; Jha et al., 2006; Gunasekera et al., 2008; Fan and Chan-Kang, 2008; Ma and Xu, 2010; Müller et al., 2010; Zhang, 2013). However, the evidence on the role of road infrastructure development on urbanization and economic growth is somewhat inconclusive, and the explanation given is plausible, but far from a clearly demonstrated answer. For example, some studies (Hulten; 1996; Canning and Pedroni; 2004; Jiwattanakulpaisarn et al., 2009a) reported that the development of road infrastructure has little or no effect on economic growth. Pravithasari et al. (2015) demonstrated that the reduced transportation cost as a results of road infrastructure development in the in Jakarta megacity contributed positively in urbanization, however, the lack of adequate investment in high mobility road infrastructure hinder the process of urbanization.

The inconclusive outcomes of road infrastructure development on urbanization and economic growth in the existing literatures has led to the formation of new hypothesis. As mention earlier in previous section, the demand and supply of roads likely varies according to the level of socioeconomic development of a country, thus, reliable information is needed on: what type of road development (i.e. high mobility or high accessibility roads) are needed during different level of country's development?

The aforementioned issues give rise to a number of questions:

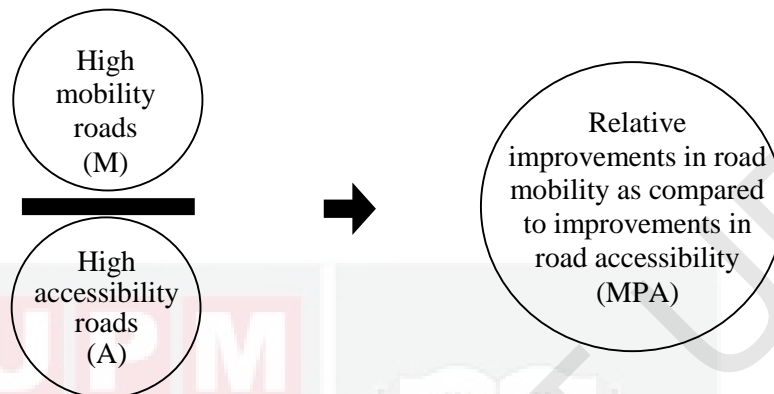
- (1) At what level of socioeconomic development is more investment needed for high accessibility roads versus high mobility roads or vice versa?
- (2) How do different road types (i.e. high mobility roads or high accessibility roads) facilitate export growth and hence economic growth?
- (3) How do different road types facilitate the process of urbanization?
- (4) What effect do different road types have on economic growth?
- (5) Do different road types have indirect effects on economic growth?

As such, this study intended to fill the gap of the research by investigating the effect of different road types needed during different level of country's development, such as during urbanization and economic growth. In order to do so, a variable, known as "relative improvements in road mobility compared to improvements in road

---

<sup>1</sup> For instance, see Chapter 2 for more details.

accessibility” or MPA was formulated as indicated in Figure 1.2 by dividing the total length of higher mobility roads by the total length of higher accessibility roads for a particular country in a particular year. This variable was used to measure the effects of different road types needed during different level of country’s development, which has not been done before in previous research.



**Figure 1.2 : Formulation of MPA to measure the effect of different road types needed during different levels of country’s development**

#### 1.4 Objectives of the Study

This general objective of this research is to evaluate the nexus between MPA, urbanization and economic growth. The specific objectives are as follows:

- (1) to evaluate how MPA facilitates export growth processes and to determine the investment level needed for different road types to facilitate economic and commercial activities at different developmental levels
- (2) to determine the investment level required for different road types in order to facilitate urbanization at different levels of urbanization and to comprehend how the development of MPA promotes export-led urban growth
- (3) to assess the indirect effect of MPA on economic growth transmitted through the impacts of MPA on urbanization and exports

#### 1.5 Significance of the Study

Previous empirical studies (Boarnet, 1997; Fernald, 1999; Hall and Pfeiffer, 2000; Hart, 2001; Liu et al., 2002; Crafts and Leunig, 2005; Handy, 2005; Xie et al., 2005; Jha et al., 2006; Gunasekera et al., 2008; Fan and Chan-Kang, 2008; Ma and Xu, 2010; Müller et al., 2010; Zhang, 2013) demonstrated that increases in road length, paved roads, highways, road density or road infrastructure development were associated with urbanization and economic growth. However, a number of gaps remain in the literature.

First, the demand for and supply of roads likely varies according to the level of urbanization and economic growth. However, no studies have examined this

hypothesis directly. Verification of this hypothesis would help to determine the investment level needed for different road types and thereby facilitate different levels of urbanization and economic growth.

Second, it is important to understand how road infrastructure growth facilitates export-led growth processes. Such knowledge can shed light on the necessity and benefits of implementing export-led growth policies, alongside road infrastructure development policies, to achieve sustainable urbanization and economic growth.

Third, it is essential to take a step further to classify the data according to the Human Development Index (HDI<sup>2</sup>) in countries with low, medium and high level of development. Investigating the effect of MPA on economic growth in countries with low, medium and high level of developments would contribute to fill the gap in the literature.

Fourth, MPA have indirect effects on urbanization and exports, with subsequent effects on economic growth. Consequently, economic growth may rise at particular levels of MPA and decline at other levels. The total effect of MPA was computed by adding the two indirect effects of MPA (its effect on urbanization and its effect on exports).

Therefore, this dissertation is expected to provide a better understanding of the influence of MPA on urbanization and economic growth. This information is crucial to help the policy makers formulate policies to sustain economic growth.

## **1.6 Scopes of the Study**

This study focused on MPA, urbanization and economic growth in a sample (N = 1174) of 60 countries with different levels of development and growth over a 31-year-period (1980 to 2010). The sources of all data used were drawn from,

- (1) International Road Federation (IRF)
- (2) Penn World Table 7.1 (PWT 7.1), published by the Centre for International Comparison of Production, Income and Prices at the University of Pennsylvania, United States
- (3) World Development Indicator (WDI)
- (4) World Bank Education Statistics (WBES)
- (5) Human Development Index (HDI), published by the United Nations Development Programme (UNDP)

---

<sup>2</sup> The HDI is a composite index used to describe the average achievement in human development. This data was published by the United Nations Development Programme (UNDP) annually. It consists of three components: long and healthy life, knowledge and a decent standard of living. These components are measured by considering the life expectancy at birth, mean and expected years of schooling, and gross national income per capita in a nation (UNDP, 2015).



The sample size of 60 countries was chosen due to missing observations in the panel data especially data from IRF. The countries chosen were those with at least a minimum of 5 years' observations during the study period to provide relatively comprehensive and reliable data set for analysing the research problem.

## **1.7 Outline of the Dissertation**

This dissertation aims to evaluate the importance of MPA in terms of urbanization and economic growth. It focuses on three empirical studies and is structured into five chapters. To provide a context within which to consider these empirical studies, relevant literature is discussed in Chapter 2.

Chapter 2 provides the literature review of the research. An overview on global development trends in road infrastructure according to the types of roads studied herein are discussed to aid understanding of road infrastructure development. Moreover, empirical works on road infrastructure development, as well as on urbanization and economic growth were also discussed. It documents the nature of the road infrastructure development, urbanization and economic growth nexus, methodologies employed in previous research and key findings from the empirical studies.

Chapter 3 outlines the methodology of the research. The theoretical frameworks, research methodology and the setting of the study within the framework of the available methodological constructs and theories. An overview on current theories and the changing nature of the relationships between road infrastructure development and socioeconomic development is also provided. This chapter also focuses on the data collection process and the methodology employed in analysing the data.

Chapter 4 presents the results and discussions of the research. A total of three empirical investigation was conducted. The first empirical investigation evaluate the relationship between MPA and economic growth. A number of variables related to the fundamental development of a country, such as the per capita exports level, per capita education level, physical capital stock per worker and urbanization level (ratio of urban to total population), are included to account for this relationship. The empirical method used in investigating the relationship between MPA and economic growth is a fixed-effects panel linear regression model. The model uses panel data from 60 countries at various levels of economic growth between 1980 and 2010. The data are divided into three levels of country development according to the HDI. The second empirical investigation analyses the relationship between MPA and urbanization. Similar variables as describe in the first empirical research are used. However, the urban to rural population ratio, is used as a proxy for urbanization rather than urban to total population ratio. The methodology employed is also the fixed-effects panel linear regression method. The third empirical study examines the indirect effects of MPA on economic growth. The indirect effects are transmitted through the impacts of MPA on urbanization and exports. The sum of both the indirect effects of MPA are computed

to explain the overall effect of MPA on economic growth.

Chapter 5 is the final chapter that concludes the research. This chapter provides the main findings of the dissertation, research contributions, policy implications, limitations and directions for future research.



## REFERENCES

- Aghion, P., Howitt, P., 1998. *Endogenous growth theory*. Cambridge, MA: MIT Press.
- Aghion, P., Howitt, P., 2009. *The economics of growth*. Cambridge, MA: MIT Press.
- Agnello, R.J., 1977. Economic evaluation of highway system benefits. *Transportation Research*, 11(5), 365-369.
- Alam, S., 1989. Anatomy of corruption: An approach to the political economy of underdevelopment. *American Journal of Economics and Sociology*, 48, 441-456.
- Albarran, P., Carrasco, R., Holl, A., 2013. Domestic transport infrastructure and firms export market participation. *Small Business Economics*, 40(4), 879-898.
- Aljoufie, M., Brussel, M., Zuidgeest, M., van Maarseveen, M., 2013a. Urban growth and transport infrastructure interaction in Jeddah between 1980 and 2007. *International Journal of Applied Earth Observation and Geoinformation*, 21, 493-505.
- Aljoufie, M., Zuidgeest, M., Brussel, M., van Maarseveen, M., 2013b. Spatial-temporal analysis of urban growth and transportation in Jeddah City, Saudi Arabia. *Cities*, 31, 57-68.
- Alonso, W., 1964. *Location and land use: toward a general theory of land rent*. Cambridge: Harvard University Press.
- Amador-Jimenez, L., Willis, C.J., 2012. Demonstrating a correlation between infrastructure and national development. *International Journal of Sustainable Development & World Ecology*, 19, 197-202.
- Arrow, K.J., 1962. The economic implications of learning by doing. *Review of Economic Studies*, 29, 155-73.
- Artuc, E., Iooty, M., Pirlea, A.F., 2014. Export performance and geography in Croatia. *World Bank Policy Research Working Paper*, 6999. Washington D.C: World Bank.
- Asian Development Bank, 2019. Projects and tenders. [https://www.adb.org/projects/sector/transport-1064/sector/transport-and-ict-1372/status/closed-1361?sort\\_by=field\\_date\\_content&sort\\_order=ASC](https://www.adb.org/projects/sector/transport-1064/sector/transport-and-ict-1372/status/closed-1361?sort_by=field_date_content&sort_order=ASC), accessed January 2019.
- Aschauer, D.A., 2000. Public capital and economic growth: issues of quantity, finance and efficiency. *Economic Development and Cultural Change*, 48(2), 391-406.



- Atack, J., Bateman, F., Haines, M., Margo, R.A., 2010. Did railroads induce or follow economic growth? Urbanization and population growth in the American Midwest, 1850-1860. *Social Science History*, 34(2), 171-197.
- Aw, B.Y., Chung, S., Roberts, M., 2000. Productivity and turnover in the export market: micro evidence from Taiwan and South Korea. *The World Bank Economic Review*, 14(1), 1-65.
- Bairoch, P., 1988. *Cities and economic development*. University of Chicago Press.
- Bakirtas, T., Akpolat, A.G., 2018. The relationship between energy consumption, urbanization and economic growth in new emerging market countries. *Energy*, 147, 110-121.
- Balassa, B., 1978. Exports and economic growth: further evidence. *Journal of Development Economics*, 5, 181-189.
- Balassa, B., 1985. Exports, policy choices, and economic growth in developing countries after the 1973 oil shock. *Journal of Development Economics*, 18, 23-35.
- Baltagi, B.H., 2005. *Econometric analysis of panel data*. New York: John Wiley and Sons Inc.
- Baltagi, B.H., Song, S.H., Jung, B.C., Koh, W., 2007. Testing for serial correlation, spatial autocorrelation and random effects using panel data. *Journal of Econometrics*, 140, 5-51.
- Banerjee, A., Duflo, E., Qian, N., 2012. On the road: access to transportation infrastructure and economic growth in China. National Bureau of Economic Research.
- Barossi-Filho, M., Silva, R.G., 2005. The empirics of the Solow growth model: long-term evidence. *Journal of Applied Economics*, 8, 31-51.
- Barro, R.J., 1990. Government spending in a simple model of endogenous growth. *Journal of Political Economy*, 98, 103-125.
- Barro, R.J., 1991. Economic growth in a cross section of countries. *The Quarterly Journal of Economics*, 407-443.
- Baumol, W.J., 1990. Entrepreneurship: productive, unproductive, and destructive. *Journal of Political Economy*, 98, 893-921.
- Benhabib, J., Spiegel, M.M., 2005. Human capital and technology diffusion. In: Aghion, P., Durlauf, S., *Handbook of Economic Growth*. North-Holland, Amsterdam: Elsevier, 935-966.
- Bernanke B., Gurkaynak R.S., 2001. Is growth exogenous? Taking Mankiw, Romer and Weil seriously, NBER Working Paper No. 8365.

- Bernard, A.B., Jensen, J.B., 1999. Exceptional exporter performance: cause, effect or both? *Journal of International Economics*, 47(1), 1-25.
- Bero, L.A., Grilli, R., Grimshaw, J.M., Harvey, E., Oxman, A.D., Thomson, M.A., 1998. Closing the gap between research and practice: an overview of systematic reviews of interventions to promote the implementation of research findings. *The BMJ*, 317 (7156), 465-469.
- Bertinelli, L., Black, D., 2004. Urbanization and growth. *Journal of Urban Economics*, 56, 80-96.
- Bevan, A.A., Danbolt, J., 2004. Testing for inconsistencies in the estimation of UK capital structure determinants. *Applied Financial Economics*, 14(1), 55-66.
- Bhagwati, J.N., 1988. *Protectionism*. Cambridge, MA: The MIT Press.
- Binswanger, H., Yang, M., Bowers, A., 1987. On the determinants of cross-country aggregate agriculture supply. *Journal of Econometrics*, 36(1-2), 111-113.
- Blakely, E.J., Leigh, N.G., 2010. *Planning local economic growth: theory and practice*. 4<sup>th</sup> Ed. Thousand Oaks, CA: SAGE Publications.
- Blyde J.S., 2012. *Paving the road to export: assessing the trade impacts of road quality*. Working paper IDB-WP-465, Inter-American Development Bank, Washington DC, USA.
- Boarnet, M.G., 1997. Highways and economic productivity: interpreting recent evidence. *Journal of Planning Literature*, 11(4), 476-486.
- Brotchie, J., 1991. Fast rail networks and socio economic impacts. In: Brotchie, J., Batty, M., Hall, P., Newton, P. *Cities of the 21st century: new technologies and spatial systems*. New York: Longman Cheshire.
- Brückner, M., 2012. Economic growth, size of the agricultural sector, and urbanization in Africa. *Journal of Urban Economics* 71, 26-36.
- Brüderl, J., Ludwig, V., 2015. Fixed-effects panel regression. *Sage Handbook of Regression Analysis and Causal Inference*, 327-356.
- Brueckner, J. K., 1987. The structure of urban equilibria: a unified treatment of the Muth-Mills model. *Handbook of Urban and Regional Economics*, Volume 2, Amsterdam: Elsevier.
- Brühlhart, M., Sbergami, F., 2009. Agglomeration and growth: cross-country evidence. *Journal of Urban Economics*, 65(1), 48-63.
- Bulsara, H.P., Chandwani, J., Gandhi, S., Miniaoui, H., 2014. Support system for women entrepreneurship in India, Saudi Arabia, United Arab Emirates, China, Uganda and Russia: a comparative exploratory study. *Man in India*, 94(4)(II), 879-913.

- Campi, M., Nuvolari, A., 2015. Intellectual property protection in plant varieties: a worldwide index (1961-2011). *Research Policy*, 44, 951-964.
- Canning D., Bennathan, E., 2000. The social rate of return on infrastructure investments. Development Research Group, Public Economics and Private Sector Development and Infrastructure Group, World Bank.
- Canning, D., Pedroni, P., 2004. The effect of infrastructure on long run economic growth. Harvard University, Williams College.
- Caselli F., 2004. Accounting for cross-country income differences, NBER Working Paper No. 10828.
- Caselli F., Feyrer J., 2005. The marginal product of capital, NBER Working Paper No. 11551.
- Castells, D., 2011. Agglomeration, inequality and economic growth: cross-section and panel data analysis. Research Institute of Applied Economic Working Paper 2011/14.
- Cavalcanti, T., Da Mata, D., Toscani, F., 2016. Winning the oil lottery: the impact of natural resource extraction on growth. IMF Working Paper WP/16/61, International Monetary Fund.
- Chandra, A., Thompson, E., 2000. Does public infrastructure economic activity? Evidence from rural interstate highway system. *Regional Science and Urban Economics*, 30, 457-490.
- Chenery, H.B., Taylor, L., 1968. Development patterns: among countries and over time. *The Review of Economics and Statistics*, 50, 391-416.
- Cheng, C., 2013. Dynamic quantitative analysis on Chinese urbanization and growth of service sector. Proceedings of 2<sup>nd</sup> International Conference on Logistics, Informatics and Service Science, 663-670.
- Coşar, A.K., Demir, B., 2016. Domestic road infrastructure and international trade: evidence from Turkey. *Journal of Development Economics*, 118, 232-244.
- Crafts, N., T. Leunig. 2005. The historical significance of transport for economic growth and productivity. Eddington Transport Study: Research Annexes Volume 1.
- Crego A., Larson D., Butzer R., Mundlak, Y., 1998. A new database of investment and capital for agriculture and manufacture. World Bank, Working Paper No 2013, Washington D.C.
- Dauda, R.O.S. (2010). Investment in education and economic growth in Nigeria: an empirical evidence. *International Research Journal of Finance and Economics*, 55, 158-169.

- Davis, J., Henderson, J.V., 2001. Evidence on the political economy of the urbanization process. *Journal of Urban Economics*, 53(1), 98-125.
- De Loecker, J., 2007. Does export generate higher productivity? Evidence from Slovenia. *Journal of International Economics*, 73, 69-98.
- DeFries, R.S., Rudel, T., Uriarte, M., Hansen, M., 2010. Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience*, 3, 178-181.
- Del Monte, A., Papagni, E., 2001. Public expenditure, corruption, and economic growth: the case of Italy. *European Journal of Political Economy* 17, 1-16.
- Dercon, S., Giligan, D.O., Hoddinott, J., Woldehanna, T., 2009. The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *American Journal of Agricultural Economics*, 91(4), 1007-1021.
- Dodaro, S., 1991. Comparative advantage, trade and growth: export-led growth revisited. *World Development*, 19(9), 1153-1165.
- Doucouiagos, C., Ulubasoglu, M.A., 2006. Economic freedom and economic growth: does specification make a difference? *European Journal of Political Economy*. 22, 60–81.
- Dulac, J., 2013. Global land transport infrastructure requirements-estimating road and railway infrastructure capacity and cost to 2050. International Energy Agency.
- Duranton, G., Puga, D., 2004. Micro-foundations of urban agglomeration economies. In: Henderson, J.V., Thisse, J.F. *Handbook of Urban and Regional Economics*, 4, North-Holland, Amsterdam, 2063-2117.
- Easterly, W.R., 2007. Free market and economic growth. *International Symposium on Poverty Reduction and Beyond Development Strategies for Low Income Countries*.
- Eaton, J., Eckstein, Z., 1997. Cities and growth: theory and evidence from France and Japan. *Regional Science and Urban Economics*, 27(4-5), 443-474.
- Elhorst, J.P., 2004. Serial and spatial error dependence in space–time models. In: Getis, A., Mur, J., Zoller, H. *Spatial Econometrics and Spatial Statistics*. Palgrave Macmillan.
- Elhorst, J.P., 2010a. Dynamic panels with endogenous interaction effects when T is small. *Regional Science and Urban Economics*, 40(5), 272-282.
- Elhorst, J.P., 2010b. Spatial panel data models. In: Fischer, M.M., Getis, A. *Handbook of Applied Spatial Analysis: Software Tools, Methods and Applications*. Springer, Berlin, 377–407.

- Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P.J., McDonald, R.I., Parnell, S., Gollin, D., Parente, S.L., Rogerson, R., 2007. The food problem and the evolution of international income levels. *Journal of Monetary Economics*, 54(4), 1230–1255.
- Elmqvist, T., Redman, C.L., Barthel, S., Costanza, R., 2013. Chapter 2 – History of urbanization and the missing ecology. In: Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P.J., McDonald, R.I., Parnell, S., Schewenius, M., Sendstad, M., Seto, K.C., Wilkinson, C. *Urbanization, biodiversity and ecosystem services: challenges and opportunities – a global assessment*. Springer Netherlands.
- Emery, R.F., 1967. The relation of exports and economic growth. *KYKLOS International Review for Social Sciences*, 20(4), 470-486.
- Esfahani, H.S., 1991. Exports, imports, and economic growth in semi-industrialized countries. *Journal of Development Economics*, 35, 93-116.
- Fafchamp, M., Shilpi, F., 2003. Spatial division of labor in Nepal. *Journal of Development Studies*, 39(6), 23-66.
- Fafchamp, M., Shilpi, F., 2005. Cities and specialization: evidence from South Asia. *Economic Journal*, 115(503), 477-504.
- Fan, F., Wang, Y., Qiu, M., Wang, Z., 2009. Evaluating the temporal and spatial urban expansion patterns of Guangzhou from 1979 to 2003 by remote sensing and GIS methods. *International Journal of Geographical Information Science*, 23(11), 1371-1388.
- Fan, S., Chan-Kang, C. 2004. Road development, economic growth, and poverty reduction in China. Development Strategy and Governance Division, International Food Policy Research Institute, USA. DSDG Discussion Paper No. 12.
- Fan, S., Chan-Kang, C., 2008. Regional road development, rural and urban poverty: Evidence from China. *Transport Policy*, 15, 305-314.
- Fan, S., Zhang, L., Zhang, X., 2002. Growth, inequality and poverty in rural China, the role of public investment. Research Report 125. Washington, D.C.: International Food Policy Research Institute.
- Fay, M., Opal, C., 2000. Urbanization without growth: a not so uncommon phenomenon. World Bank Policy Research Working Paper 2412.
- Feder, G., 1982. On exports and economic growth. *Journal of Development Economics* 12, 59-73.



- Federal Highway Administration (FHWA), 2017. Access management principles presentation. Department of Transportation, Federal Highway Administration. Available at [https://ops.fhwa.dot.gov/access\\_mgmt/progplan.htm](https://ops.fhwa.dot.gov/access_mgmt/progplan.htm), accessed in March 2018.
- Fernald, J.G., 1999. Roads to prosperity? Assessing the link between public capital and productivity. *The American Economic Review*, 89(3), 619-638.
- Firebaugh, G., 1979. Structural determinants of urbanization in Asia and Latin America, 1950-1970. *American Sociology Review*, 44(2), 199-215.
- Flückiger, M., Ludwig, M., 2018. Geography, human capital and urbanization: a regional analysis. *Economics Letters*, 168, 10-14.
- Fosu, A.K., 1990a. Exports and economic growth: the African case. *World Development*, 18(6), 831-835.
- Fosu, A.K., 1990b. Export composition and the impact of exports on economic growth of developing economies. *Economics Letters*, 34, 67-71.
- Friedlaender, A.F., 1965. *The interstate highway system: a study in public investment*. Amsterdam: North-Holland Publishing Company.
- Fujita, M., 1988. A monopolistic competition model of spatial agglomeration: differentiated product approach. *Regional Science and Urban Economics*, 18 (1), 87-124.
- Fujita, M., Krugman, P., Mori, T., 1999. On the evolution of hierarchical urban systems. *European Economic Review*, 43(2), 209-251.
- Fujita, M., Ogawa, H., 1982. Multiple equilibria and structural transition of non-monocentric urban configurations. *Regional Science and Urban Economics*, 12(2), 161-196.
- Gabardo, F.A., Pereima, J.B., Einloft, P., 2017. The incorporation of structural change into growth theory: a historical appraisal. *Economía*, 18(3), 392-410.
- Gabrielle, A., 2004. Exports of services and economic growth for developing countries. United Nations Conference on Trade and Development, Division on International Goods and Services, and Commodities (UNCTAD), UNCTAD/DITC/TNCD/MISC/2003/6.
- Glaeser, E.L., Kahn, M.E., 2004. Sprawl and urban growth. *Handbook of Urban and Regional Economics*, Volume 4. Amsterdam: Elsevier.
- Glaeser, E.L., 2008. *Cities, agglomeration and spatial equilibrium*. Oxford, Inglaterra: Oxford University Press.
- Gollin, D., Jedwab, R., Vollrath, D., 2016. Urbanization with and without industrialization. *Journal of Economic Growth*, 21, 35-70.

- Gollin, D., Parente, S.L., Rogerson, R., 2007. The food problem and the evolution of international income levels. *Journal of Monetary Economics*, 54(4), 1230–1255.
- Gramlich, E. 1994. Infrastructure investments: a review essay. *Journal of Economic Literature*, 32(3), 1177-1196.
- Greene, W.H., 2003. *Econometric Analysis*. 5th Eds. Prentice Hall.
- Grewal, R., Cote, J., Baumgartner, H., 2004. Multicollinearity and measurement error in structural equation models: implications for theory testing. *Marketing Science*, 23(4), 519-529.
- Griliches, Z., 1980. R&D and the productivity slowdown. NBER Working Paper Series 0434. National Bureau of Economic Research, Inc.
- Gujarati, D.N., 2004. *Basic Econometrics*. 4<sup>th</sup> Ed. New York: McGraw-Hill.
- Gunasekera, K., Anderson, W., Lakshmanan, T.R., 2008. Highway-induced development: evidence from Sri Lanka. *World Development*, 36(11), 2371-2389.
- Hall B.H., Cummins C., Laderman E.S., Mundy J., 1988. The R&D master file documentation, NBER Technical Working Paper No. 72.
- Hall, P., Pfeiffer, U., 2000. *Urban future 21: a global agenda for twenty-first century cities*. Spon, London.
- Hall, R.E., Jones, C.I., 1999. Why do some countries produce so much more output per worker than others? *Quarterly Journal of Economics*, 114(1), 83-116.
- Han, X., Wu, P.L., Dong, W.L., 2012. An analysis on interaction mechanism of urbanization and industrial structure evolution in Shandong, China. *Procedia Environmental Sciences*, 13(1), 1291-1300.
- Handy, S., 2005. Smart growth and the transportation-land use connection: what does the research tell us? *International Regional Science Review*, 28(2), 146-167.
- Hanushek, E.A., Woessmann, L., 2008. The role of cognitive skills in economic growth. *Journal of Economic Literature*, 46(3), 607-668.
- Hart, T., 2001. Transportation and the city. In: Paddison, R., *Handbook of Urban Studies*. Sage, London, 102-121.
- He, X., Sim, N.C.S., 2015. Does economic growth affect urbanization? New evidence from China and the Chinese National Congress. *Journal of Asian Economics*, 36, 62-71.
- Heller, P.S., Porter, R.C., 1978. Exports and growth: An empirical re-investigation. *Journal of Development Economics*, 5(2), 191-193.

- Helpman, E., Krugman, P.R., 1985. Market structure and foreign trade. Cambridge, MA: MIT Press.
- Henderson, J.V., 2003. The urbanization process and economic growth: the so-what question. *Journal of Economy Growth*, 8, 47-71.
- Henderson, J.V., Roberts, M., Storeygard, A., 2013. Is urbanization in Sub-Saharan Africa different? Policy Research Working Paper No. WPS 6481. Washington, DC: World Bank.
- Henderson, J.V., Thisse, J.F., 2004. Handbook of Regional and Urban Economics. Elsevier, Ed. 1, Vol. 1, No. 4
- Henderson, V., 2003. The urbanization process and economic growth: the so-what question. *Journal of Economy Growth*, 8, 47-71.
- Herrerias, M. J., Orts, V., 2010. Is the export-led growth hypothesis enough to account for China's growth? *China & World Economy*, 18(4), 34-51.
- Heston, A., Summers, R., Aten, B., 2012. Penn World Table Version 7.1. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania. [https://pwt.sas.upenn.edu/php\\_site/pwt71/pwt71\\_form.php](https://pwt.sas.upenn.edu/php_site/pwt71/pwt71_form.php), accessed in January 2015.
- Hossain, M.S., 2011. Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy*, 39(11), 6991-6999.
- Hou, Q., Li, S., 2011. Transport infrastructure development and changing spatial accessibility in the Greater Pearl River Delta, China, 1990-2010. *Journal of Transport Geography*, 19, 1350-1360.
- Hsiao, C., 2003. Analysis of panel data. 2<sup>nd</sup> Ed, Cambridge University Press, Cambridge, UK.
- Huff, G., 2012. Export-led growth, gateway cities and urban system development in Pre-World War II Southeast Asia. *The Journal of Development Studies*, 48(10), 1431-1452.
- Hulten, C.R., 1996. Infrastructure capital and economic growth: how well you use it may be more important than how much you have. National Bureau of Economic Research, Inc, Working Paper 5847.
- Hulten, C.R., Bennathan, E., Srinivasan, S., 2006. Infrastructure, externalities and economic development: a study of the Indian manufacturing industry. *World Bank Economic Review*, 20(2), 291-308.
- Iimi, A., 2005. Urbanization and development of infrastructure in the East Asian region. *JBICI Review*, 10, 88-109.



- IRF World Road Statistics, 2010. IRF World Road Statistics 2010: Data 1963-2008. International Road Federation: Geneva.
- IRF World Road Statistics, 2012. IRF World Road Statistics 2012: Data 2005-2010. International Road Federation: Geneva.
- IRF World Road Statistics, 2015. IRF World Road Statistics 2015: Data 2005-2013. International Road Federation: Geneva.
- Jacobs, J., 1969. *The economy of cities*. New York: Random House.
- Jedwab, R., 2013. *Urbanization without industrialization: evidence from consumption cities in Africa*. Unpublished manuscript, Department of Economics, George Washington University.
- Jha, M.K., Asce, M., Kim, E., 2006. Highway route optimization based on accessibility, proximity, and land use changes. *Journal of Transportation Engineering-ASCE*, 132(5), 435-439.
- Jiminez, G.H., Razmi, A. 2013. Can Asia sustain an export-led growth strategy in the aftermath of the global crisis? Exploring a neglected aspect. *Journal of Asian Economics*, 29, 45-61.
- Jiwattanakupaisarn, P., Noland, R.B., Graham, D.J., Polak, J.W., 2009a. Highway infrastructure investment and county employment growth: a dynamic panel regression analysis. *Journal of Regional Science*, 49 (2), 263-286.
- Jiwattanakupaisarn, P., Noland, R.B., Graham, D.J., Polak, J.W., 2009b. Highway infrastructure and state-level employment: a causal spatial analysis. *Papers in Regional Science*, 88(1), 133-160.
- Judge, G.G., Hill, R.C., Griffiths, W.E., Lutkepohl, H., Lee, T.C., 1988. *Introduction to the theory and practice of econometrics*. 2nd Ed. New York: John Wiley and Sons.
- Junius, K., 1999, Primacy and economic development: bell shaped or parallel growth of cities. *Journal of Economic Development*, 24(1), 1-22.
- Kalb, M., Saivetz, C., 2007. The Israeli-Hezbollah War of 2006: the media as a weapon in asymmetrical conflict. *The International Journal of Press/ Politics*, 12(3), 43-66.
- Kavousi, R.M., 1984. Export expansion and economic growth: further empirical evidence. *Journal of Development Economics* 14, 241-250.
- Keeler, T.E., Ying, J.S., 1988. Measuring the benefits of a large public investment: the case of the U.S. federal-aid highway system. *Journal of Public Economics*, 36(1), 69-85.
- Keesing, D.B., 1967. Outward-looking, policies and economic development. *Economic Journal*, 77(306), 303-320.

- Konishi, H., 2000. Formation of hub cities: transportation cost advantage and population agglomeration. *Journal of Urban Economics*, 48(1), 1-28.
- Koopmans, C., Rietveld, P., Huijg, A., 2012. An accessibility approach to railways and municipal population growth. *Journal of Transport Geography*, 25, 98-104.
- Krueger, A.O., 1978. *Foreign trade regimes and economic development: liberalization attempts and consequences*, Cambridge, Mass: Ballinger Publishing Company.
- Krugman, P. 1991. Increasing returns and economic geography. *Journal of Political Economy*, 99(3), 483-499.
- Kuznets, S., 1966. *Modern economic growth*. New Haven, CT: Yale University Press.
- Lacono, M., Levinson, D., 2016. Mutual causality in road network growth and economic development. *Transport Policy*, 45, 209-217.
- Law, T.H., Noland, R.B., Evans, A.W., 2010. The direct and indirect effects of corruption on motor vehicle crash deaths. *Accident Analysis and Prevention*, 42, 1934-1942.
- Lawrence, R.Z., Weinstein, D.E., 1999. Trade and growth: import-led or export-led? Evidence from Japan and Korea. NBER working paper No. 7264. <http://www.nber.org/papers/w7264>, accessed in January 2016.
- Lee, E.S., 1966. A general theory of migration. *Demography*, 3(1), 37-47.
- Lee, L.F., Yu, J., 2012. Spatial panels: random components versus fixed effects. *International Economic Review*, 53(4), 1369-1412.
- Levine, R., 2005. Finance and growth: theory and evidence. In: Aghion, P., Durlauf, S. *Handbook of Economic Growth*. The Netherlands: Elsevier Science.
- Levrero, E.S., Palumbo, A., Stirati, A., 2013. *Sraffa and Reconstruction of Economy Theory: Volume Two: Aggregate Demand, Policy Analysis and Growth*. London, United Kingdom: Palgrave Macmillan.
- Lewis, A., 1954. Economic development with unlimited supplies of labour. *The Manchester School*, 22(2), 139-191.
- Li, H., Xu, L.C., Zou, H.F., 2000. Corruption, income distribution, and growth. *Economics and Politics*, 12, 155-182.
- Lin, T., Truong, T.P., 2012. Transport improvement, agglomeration effect and urban productivity: the case of Chinese cities. Working Paper ITLS-WP-12-12, Institute of Transport and Logistics Studies, The Australian Key Centre in Transport and Logistics Management, The University of Sydney, NSW 2006 Australia.

- Litman, T., 1995. Land use impact costs of transportation. *World Transport Policy Practice*, 1(4), 9-16.
- Liu, S., Sylvia, P., Li, X., 2002. Spatial patterns of urban land use growth in Beijing. *Journal of Geographical Sciences*, 12(3), 266-274.
- Liu, T., Su, C.W., Jiang, X., 2014. Is economic growth improving urbanisation? A cross-sectional study of China. *Urban Studies*, 1-16.
- Liu, Y., 2009. Exploring the relationship between urbanization and energy consumption in China using ARDL (Autoregressive distributed lag) and FDM (Factor decomposition model), *Energy*, 34, 1846-1854.
- Liu, Y., Yan, B., Zhou, Y., 2016. Urbanization, economic growth and carbon dioxide emissions in China: a panel cointegration and causality analysis. *Journal of Geographical Science*, 26(2), 131-152.
- London, B., 1987. Structural determinants of third world urban change: an ecological and political economic analysis. *American Sociological Review*, 52(1), 28-43.
- Lucas, R. E., 1988. On the mechanics of economic development. *Journal of Monetary Economics*, 22, 3-42.
- Lucas, R.E., 2004. Life earnings and rural-urban migration. *Journal of Political Economy*, 112(S1), S29-S59.
- Ma, Q., He, C., Wu, J., 2016. Behind the rapid expansion of urban impervious surfaces in China: major influencing factors revealed by a hierarchical multiscale analysis. *Land Use Policy*, 59, 434-445.
- Ma, Y., Xu, R., 2010. Remote sensing monitoring and driving force analysis of urban expansion in Guangzhou city, China. *Habitat International*, 34(2), 228-235.
- Mamun, K. A., Nath, K., 2005. Export-led growth in Bangladesh: a time series analysis. *Applied Economics Letters*, 12, 361-364.
- Mamuneas, T.P., Nadiri, M.I., 2006. Production, consumption and the rates of return to highway infrastructure capital (unpublished manuscript). University of Cyprus, New York University and National Bureau of Economic Research.
- Maneschild, P.O., 2008. A note on the export-led growth hypothesis: a time series approach. *Cuadernos De Economia*, 45, 293-302.
- Mankiw, N.G., Romer, D., Weil, D.N., 1992. A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 407-437.
- Marmara, A.D., Usman, S.I., 2015. An economic analysis of urbanization and economic growth in the Republic of China. *Proceedings of the International Symposium on Emerging Trends in Social Science Research, Chennai-India*, Paper ID: C535.

- Marshall, A., 1890. Principles of economics. London: Macmillan.
- Mauro, P., 1997. The effects of corruption on growth, investment, and government expenditure: a cross country analysis. In: Elliot, K.A. Corruption and the Global Economy. Washington: Institute for International Economics.
- Medina-Smith, E.J. 2001. Is the export-led growth hypothesis valid for developing countries? A case study of Costa Rica. Policy Issues in International Trade and Commodities Study Series No. 7, United Nations Conference on Trade and Development.
- Meinel, G., Reichert, S., Killisch, W., 2007. Entwicklung und Raumwirkung des deutschen Autobahnnetzes (Development of the German motorways). Photogramm Fernerkun, 261-274 [in German].
- Mercan, M., Sezer, S., 2014. The effect of education expenditure n economic growth: the case of Turkey. Procedia-Social and Behavioural Sciences, 109, 925-930.
- Meyer, M. D., Miller, E. J., 2001. Urban Transportation Planning. 2<sup>nd</sup> Ed. New York: McGraw Hill.
- Michaels, G., 2008. The effect of trade on the demand for skill: evidence from the interstate highway system. The Review of Economics and Statistics, 90, 683-701.
- Michaely, M., 1977. Exports and growth: an empirical investigation. Journal of Development Economics, 4, 49-53.
- Mills, E.S., 1967. An aggregate model of resource allocation in a metropolitan area. The American Economic Review, 57, 197-210.
- Mills, E.S., 1972. Studies in the structure of the urban economy. Baltimore: Johns Hopkins University Press.
- Mitra, A., 2000. Total factor productivity growth and urbanization economies: a case of Indian industries. Review of Urban & Regional Development Studies, 12(2), 97-108.
- Mo, P.H., 2001. Corruption and economic growth. Journal of Comparative Economics, 29, 66-79.
- Moomaw, R.L., Shatter, A.M., 1993. Urbanization as a factor in economic growth. Journal of Economics, 19, 1-6.
- Moomaw, R.L., Shatter, A.M., 1996. Urbanization and economic development: a bias toward large cities? Journal of Urban Economics, 40, 13-37.
- Moschos, D., 1989. Export expansion, growth and the level of economic development. Journal of Development Economics, 30, 93-102.

- Müller, K., Steinmeier, C., Kuchler, M., 2010. Urban growth along motorways in Switzerland. *Landscape and Urban Planning*, 98(1), 3-12.
- Murphy, K.M., Shleifer, A., Vishny, R.W., 1993. Why is rent-seeking so costly to growth? *The American Economic Review*, 83, 409-414.
- Muth, R.F., 1969. *Cities and housing: the spatial pattern of urban residential land use*. University of Chicago Press, Chicago
- Myrdal, G., 1968. *Asian drama: an inquiry into the poverty of nations*. New York: Pantheon.
- Nadiri, M.I. and Mamuneas, T.P., 1998. Contribution of highway capital to output and productivity growth in the US economy and industries. Federal Highway Administration, U.S. Department of Transportation, Washington DC.
- Nelson, R., Phelps, E., 1966. Investment in humans, technological diffusion and economic growth. *American Economic Association Papers and Proceedings*, 56, 69-75.
- Nsiah, C., Wu, C., Mayer, W.J., 2012. An analysis of US State's export performance in the Asian market. *The Annals of Regional Science*, 49(2), 533-550.
- Oke, D.M., Bokana, K.G., Shobande, O.A., 2017. Some correlates of rural-urban led urbanization in Lagos, Nigeria. *Review of Urban and Regional Development Studies*, 29(3), 185-195.
- Onikosi-Alliyu, S.O., 2012. Transport infrastructure and economic growth in Nigeria: causality analysis. *Journal of Business and Organizational Development*, 4, 60-66.
- Pandey, S.M., 1977. Nature and determinants of urbanization in a developing economy: the case of India. *Economic Development and Cultural Change*, 25, 265-278.
- Parent, O., LeSage, J.P., 2011. A space-time filter for panel data models containing random effects. *Computational Statistics and Data Analysis*, 55(1), 475-490.
- Parent, O., LeSage, J.P., 2012. Spatial dynamic panel data models with random effects. *Regional Science and Urban Economics*, 42(4), 727-738.
- Parker, A., 1995. Patterns of federal urban spending: central cities and their suburbs, 1983-1992. *Urban Affairs Review*, 31(2), 184-205.
- Pellegrini, L., Gerlagh, R., 2004. Corruption's effect on growth and its transmission channels. *KYKLOS*, 57, 429-456.
- Percoco, M., 2016. Highways, local economic structure and urban development. *Journal of Economic Geography*, 16(5), 1035-1054.



- Pradhan, R.P., 2007. Does infrastructure play role in urbanization: evidence from India. *Journal of Economics and Business*, 6, 81–92.
- Pradhan, R.P., Bagchi, T.P., 2013. Effect of transportation infrastructure on economic growth in India: the VECM approach. *Research in Transportation Economics*, 38, 139-148.
- Pradhan, R.P., Norman, N.R., Badir, Y., Samadhan, B., 2013. Transport infrastructure, foreign direct investment and economic growth interactions in India: the ADRL bounds testing approach. *Procedia-Social and Behavioural Sciences*, 104, 914-921.
- Preston, S.H., 1979. Urban growth in developing countries: a demographic reappraisal. *Population and Development Review*, 5(2), 195–215.
- Priemus, H., Nijkamp, P., Banister, D., 2001. Mobility and spatial dynamics: an uneasy relationship. *Journal of Transportation Geography*, 9(3), 167–171.
- Queiroz, C., Gautam, S., 1992. Road infrastructure and economic development: some diagnostic indicators. Policy Research Working Papers (WPS 921). Transport. Washington, DC: World Bank.
- Quigley, J.M., 2008. Urbanization, agglomeration, and economic development. Working Paper No. 19, Commission on Growth and Development.
- Ram, R., 1985. Exports and economic growth: some additional evidence. *Economic Development and Cultural Change*, 33(2), 415-425
- Ram, R., 1987. Exports and economic growth in developing countries: evidence from time series and cross-section data. *Economic Development and Cultural Change*, 36(1), 51-72.
- Ravenstein, E. G., 1889. The laws of migration. *Journal of the Royal Statistical Society*, 52(2), 241–310.
- Ravenstein, E.G., 1885. The laws of migration. *Journal of the Statistical Society of London*, 48(2), 167-235.
- Rode, P., Floater, G., Thomopoulos, N., Docherty, J., Schwinger, P., Mahendra, A., and Fang, W., 2014. Accessibility in cities: transport and urban form. NCE Cities Paper 03. LSE Cities. London School of Economics and Political Science.
- Romer, P.M., 1990a. Human capital and growth: theory and evidence, Carnegie Rochester Conference Series on Public Policy, 32 (1), 251-286.
- Romer, P.M., 1990b. Endogenous technological change. *Journal of Political Economy*, 99(5)(II), S71–S102.
- Rosenthal, S.S., Strange, W.C., 2004. Evidence on the nature and sources of agglomeration economies. *Handbook of Urban and Regional Economics*, Vol. 4. Amsterdam: Elsevier, 2119-2172.

- Saunders, S.C., Mislivets, M.R., Chen, J.Q., Cleland, D.T., 2002. Effects of roads on landscape structure within nested ecological units of the Northern Great Lakes Region, USA. *Biological Conservation*, 103(2), 209-225.
- Schultz, T.W., 1953. *The Economic Organization of Agriculture*. New York: McGraw-Hill.
- Setboonsarng, S., 2006. Transport infrastructure and poverty reduction. ADBI Research Policy Brief No. 21, Asian Development Bank (ADB), Manila, Philippines.
- Shao, J., Xiao, Z., Xu, R., 2011. Estimation with unbalanced panel data having covariate measurement error. *Journal of Statistical Planning and Inference*, 141(2), 800-808.
- Shleifer, A., Vishny, R.W., 1993. Corruption. *The Quarterly Journal of Economics*, 108, 599-617.
- Siliverstovs, B., Herzer, D., 2007. Manufacturing exports, mining exports, and growth: cointegration and causality analysis for Chile (1960-2001). *Applied Economics*, 39, 153-167.
- Sit, V., Yang, C., 1997. Foreign investment induced exo-urbanization in the Pearl River Delta China. *Urban Studies*, 34(4), 647-677.
- Solow, R., 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics*. 70, 65-94.
- Starkey, P., Hine, J., 2014. Poverty and sustainable transport - how transport affects poor people with policy implications for poverty reduction - a literature review. UN-Habitat.
- Stephanedes, Y.J., Eagle, D., 1987. Highway impacts on regional employment. *Journal of Advanced Transportation*, 21, 67-79.
- Su, L., Yang, Z., 2015. QML estimation of dynamic panel data models with spatial errors. *Journal of Econometrics*, 185(1), 230-258.
- Syron, R.F., Walsh, B.M., 1968. The relation of exports and economic growth: a note. *KYKLOS*, 21(3), 541-545.
- Tanzi, V., Davoodi, H., 1998. Corruption, public investment, and growth. In: Shibata, H., Ihoti, T., *The welfare state, public investment and growth*. Japan: Springer Verlag, 41-60.
- Tian, G.J., Wu, J.G., 2015. Comparing urbanization patterns in Guangzhou in China and Phoenix in the USA: the influences of roads and rivers. *Ecological Indicators*, 52, 23-30.
- Tsekeris, T., 2017. Domestic transport effects on regional export trade in Greece. *Research in Transportation Economics*, 61, 2-14.



- Tyler, W.G., 1981. Growth and export expansion of developing countries: some empirical evidence. *Journal of Development Economics*, 9(1), 121-30.
- United Nations Development Programme (UNDP), 2015. Human Development Index. Available at: <http://hdr.undp.org/en/content/human-development-index-hdi>, accessed in May 2015.
- United Nations, 2014. World urbanization prospects: the 2014 Revision. United Nations, New York. <http://esa.un.org/unpd/wup/>, accessed in August 2017.
- Van Biesebroeck, J., 2005. Exporting raises productivity in Sub-Saharan African manufacturing firms. *Journal of International Economics*, 67(2), 373-391.
- Vandenbussche, J., Aghion, P., Meghir, C., 2006. Growth, distance to frontier and composition of human capital. *Journal of Economic Growth*. 11, 97-127.
- Verbeek, M., 2004. A Guide to modern econometrics. 2<sup>nd</sup> Ed. Erasmus University Rotterdam, John Wiley and Sons Ltd., Hoboken.
- Volpe Martincus, C., Blyde, J., 2013. Shaky roads and trembling exports: assessing the trade effects of domestic infrastructure using a natural experiment. *Journal of International Economics*, 90, 148-161.
- Volpe Martincus, C., Carballo, J., Cusolito, A., 2014a. Routes, exports and employment in developing countries: following the traces of the Inca roads. Inter-American Development Bank, Washington DC.
- Volpe Martincus, C., Carballo, J., Cusolito, A., 2017. Roads, exports and employment: evidence from a developing country. *Journal of Development Economics*, 125, 21-39.
- Volpe Martincus, C., Carballo, J., Garcia, P.M., Graziano, A., 2014b. How do transport cost affect firms' export? Evidence from a vanishing bridge. *Economic Letters*, 123, 149-153.
- Wooldridge, J.M., 2002. *Econometric analysis of cross section and panel data*. Cambridge, MA: MIT Press.
- Wooldridge, J.M., 2012. *Introductory econometrics – a modern approach*. 5<sup>th</sup> Ed. South-Western: Cengage Learning.
- World Bank, 1961. Report and recommendations of the president to the executive directors on a proposed loan to the Argentine Republic for a highway project. Report P255, Washington, DC.
- World Bank, 1977. Report and recommendations of the president of the International Bank for Reconstruction and Development to the executive directors on a proposed loan to the Argentine Republic for a fourth highway project. Report P2003-AR, Washington, DC.

- World Bank, 2001. Project appraisal document on a proposed loan in the amount of US\$200 million to the People's Republic of China for the second Jiangxi highway project. Report 21826-CHA, Washington, DC.
- World Bank, 2015. World Development Indicators 2015. Washington, DC.
- World Bank. 2016. From oil to cities: Nigeria's next transformation. Directions in development. Washington, DC.
- Xie, Y., Gong, J., Qian, D., Sun, P., 2013. Changes and effect of landscape pattern along the National Road 312 between Jiuquan and Jiayuguan city. *Arid Zone Research* 3(6), 1056-1063 (In Chinese).
- Xie, Y., Gong, J., Sun, P., Gou, X., Xie, Y., 2016. Impacts of major vehicular roads on urban landscape and urban growth in an arid region: a case study of Jiuquan city in Gansu province, China. *Journal of Arid Environments*, 127, 235-244.
- Xie, Y., Mei, Y., Guangjin, T., Xuerong, X., 2005. Socio-economic driving forces of arable land conversion: a case study of Wuxian City, China. *Global Environmental Change*, 15(3), 238–252.
- Xing, C. 2016. Human capital and urbanization in the People's Republic of China. ADBI Working Paper 603. Tokyo: Asian Development Bank Institute.
- Yu, J., de Jong, R., Lee, L.F., 2008. Quasi-maximum likelihood estimators for spatial dynamic panel data with fixed effects when both n and T are large. *Journal of Econometrics*, 146(1), 118–134.
- Zhang, K.H., 2017. Chapter 2 – urbanization and industrial development in China. In: Tang, Z. *China's urbanization and socioeconomic impact*. Springer Nature Singapore Pte Ltd.
- Zhang, T., Klyuev, V., 2017. Roads to stronger growth in low-income countries. *IMFblog – Insights and Analysis on Economics and Finance*. International Monetary Fund. <https://blogs.imf.org/2017/01/12/roads-to-stronger-growth-in-low-income-countries/>, accessed January 2019.
- Zhang, X., 2013. Has transport infrastructure promoted regional economic growth? – With an analysis of the spatial spillover effects of transport infrastructure. *Social Sciences in China*, 34(2), 24-47.
- Zhang, X., Fan, S., 2004. How productive is infrastructure? A new approach and evidence from rural India. *American Journal of Agricultural Economics*, 86, 492-501.
- Zhang, Y., Wan, G. H., 2015. International trade and the urbanization of developing countries: Evidence from Asia. *Social Sciences in China*, 36(2), 186-204.

## BIODATA OF STUDENT

The student was born on 17<sup>th</sup> March 1979 in Kuala Lumpur, Malaysia. She received her early education in Tai Thung Kindergarten when she was 6 years old. Later on, she continued her primary and secondary education in SRJK (C) Confucian and SMK Confucian, Kuala Lumpur, respectively from 1986 to 1996. After completing her pre-university education in 1998 at SMK (L) Methodist in Kuala Lumpur, she started her study at the Universiti Putra Malaysia, Selangor. She was awarded with Bachelor of Engineering (Civil) (Hons.) majoring in Highway and Transport Engineering in 2002.

After her graduation, she work as a research assistance in Road Safety Research Centre, Universiti Putra Malaysia for 2 years. Following this, she was appointed as a highway engineer in Sepakat Setia Perunding (Sdn) Bhd and she work as a designer and consultant for 3 years. She received her Master of Science (Highway and Transport Engineering) from Universiti Putra Malaysia in 2006. In August 2007, she served as a lecturer in Universiti Pertahanan Nasional Malaysia, Kuala Lumpur. In 2011, she pursue her PhD in Highway and Transport Engineering in Universiti Putra Malaysia. Her main research interests are highway and transport studies and road safety.

## LIST OF PUBLICATIONS

- Ng, C.P., Law, T.H., Wong, S.V., Kulanthayan, S., 2017. Relative improvements in road mobility as compared to improvements in road accessibility and economic growth: a cross-country analysis. *Transport Policy*, 60, 24-33.
- Ng, C.P., Law, T.H., Jakarni, F.M., Kulanthayan, S., 2018. Relative improvements in road mobility as compared to improvements in road accessibility and urban growth: a panel data analysis. *Transportation Research Part A*, 177, 292-301.
- Ng, C.P., Law, T.H., Jakarni, F.M., Kulanthayan, S., 2018. Assessing the indirect effects of road mobility on economic growth. Original manuscript submitted to *Research in Transport Economics* on 24 April 2018 (Submission No.: RETREC\_2018\_80)
- Ng, C.P., Law, T.H., Jakarni, F.M., Kulanthayan S., 2019. Road infrastructure and economic growth. *IOP Conference Series: Materials Science and Engineering*, 512(1), 012045.



**UNIVERSITI PUTRA MALAYSIA**

**STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT**

**ACADEMIC SESSION :** \_\_\_\_\_

**TITLE OF THESIS / PROJECT REPORT :**

RELATIVE IMPROVEMENTS IN ROAD MOBILITY COMPARED TO IMPROVEMENTS IN ROAD ACCESSIBILITY, URBANIZATION AND ECONOMIC GROWTH

**NAME OF STUDENT :** NG CHOY PENG

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

\*Please tick (v )

**CONFIDENTIAL**

(Contain confidential information under Official Secret Act 1972).

**RESTRICTED**

(Contains restricted information as specified by the organization/institution where research was done).

**OPEN ACCESS**

I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

**PATENT**

Embargo from \_\_\_\_\_ until \_\_\_\_\_  
(date) (date)

**Approved by:**

\_\_\_\_\_  
(Signature of Student)  
New IC No/ Passport No.:

Date :

\_\_\_\_\_  
(Signature of Chairman of Supervisory Committee)  
Name:

Date :

[Note : If the thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted. ]