The Effect and Causality of Urbanization on Per Capita GDP in ASEAN States

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Chapter 1

Introduction

"Urbanization is the motor of history."

— Alfred Sauvy

Throughout history, the growth and development of cities has been the primary driving force behind economic progress. From the industrial revolution in 18th century Europe to the rapid growth of megacities in the developing world, urbanization has consistently played a pivotal role in shaping the course of economic development.

The question of urbanization has become increasingly relevant over the last century as millions of people have migrated from rural areas to urban ones, with 60% of the world projected to live in urban areas by 2030.[1] This phenomenon has been long coming, being the outcome of certain push and pull factors such as the availability of economic opportunities, various socio-cultural pressures, and rapidly changing fertility rates. Specifically for many developing countries such as India, the Philippines, and Indonesia, and the development of urban mega cities such as Jakarta, and Metro Manila, there have been emerging concerns regarding the potential impact of this level of urbanization on the economy and the ability of people to provide for their basic needs.

[1] United Nations, ed. *Results of the eighth United Nations inquiry among governments on population and development.* OCLC: ocm46921227. New York: United Nations, 2001. ISBN: 9789211513462.

1.1 Research Question and Significance of the Study

In this paper, we aim to analyze the effect of urbanization on economic development, specifically the average economic production made by an individual person. We also aim to look at the urbanization's causal relationships between the aforementioned indicators. Hence, the precise statement of the research question is as follows:

What is the causal effect of urbanization on per capita GDP?

As stated before, this topic has obvious and significant implications. A variety of changes/recommendations in migration policy, urban development, land planning, etc. are dependent on asking whether urban migration is economically desirable, as well as the degree to which it has an effect. Beyond policy recommendations for the current situation, analyzing such trends can also provide insight for other countries about to undergo rapid urbanization – such a topic can help countries predict and understand their own rates of development and urbanization.

The specific gap in the literature that we would aim to address is threefold; firstly in the expansion of economic indicators to include factors such as HDI, life expectancy, and educational attainment in order to broaden the scope of 'economic success', secondly, to measure the total percentage of urbanization in a country as opposed to the output of specific urbanized regions to provide an indicator that is relatively more comparable between different countries, and thirdly, to look at the causal relationships as opposed to just correlational

relationships.

1.2 Scope and Limitations

The paper will be working upon the theoretical framework and assumption that urbanization generally signals economic growth.[2] This is due to a variety of suggested reasons, such as high levels of urbanization indicating sectoral shifts from agriculture to manufacturing and services[3] or urban agglomerations creating conducive conditions for forming human capital,[4] reducing production costs,[5] and increasing competition in markets.[6]

The paper will be using urbanization data from the World Bank's World Development Indicators dataset,[7] which will specifically be the percent of the population living in urban areas. The variable for % urbanization relies on the internal reporting system between countries so actual criteria may vary, but generally will refer to people living in conurbations or cities with more

[2]Mingxing Chen et al. "The Global Pattern of Urbanization and Economic Growth: Evidence from the Last Three Decades". en. In: *PLoS ONE* 9.8 (2014). DOI: 10.1371/journal.pone.0103799. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4123908/ (visited on 12/09/2022).

[3]J. Vernon Henderson. "The Urbanization Process and Economic Growth: The So-What Question". In: *Journal of Economic Growth* 8.1 (2003), pp. 47–71. URL: https://EconPapers.repec.org/RePEc:kap:jecgro:v:8:y:2003:i:1:p:47-71.

[4]Luisito Bertinelli and Duncan Black. "Urbanization and growth". en. In: *Journal of Urban Economics* 56.1 (July 2004), pp. 80–96. ISSN: 0094-1190. DOI: 10.1016/j.jue.2004.03.003. URL: https://www.sciencedirect.com/science/article/pii/S0094119004000361 (visited on 12/09/2022).

[5]Michał Banaszak et al. "Geography in motion: Hexagonal spatial systems in fuzzy gravitation". en. In: *Environment and Planning A: Economy and Space* 51.2 (Mar. 2019), pp. 393–402. ISSN: 0308-518X, 1472-3409. DOI: 10.1177/0308518X18790249. URL: http://journals.sagepub.com/doi/10.1177/0308518X18790249 (visited on 12/09/2022).

[6]Edward L Glaeser, Stuart S Rosenthal, and William C Strange. "Urban economics and entrepreneurship". In: *Journal of urban economics* 67.1 (2010), pp. 1–14.

[7]""World Development Indicators — DataBank." Accessed December 10, 2022. https://databank.worldbank.org/source/world-development-indicators." In: ().

than a million people within a certain distance or jurisdiction.[8] These differences in measurement are accounted for by running regressions exclusively within one country over time as opposed to between multiple countries.

1.3 Definition of Terms

GDP per capita PPP-adjusted (current international $) from the World Bank's, World Development Indicators are defined as "gross domestic product (GDP) expressed in current international dollars, converted by purchasing power parity (PPP) conversion factor." originating from the International Comparison Program and the Eurostat-OECD PPP Programme summarized annually.[9]

Urban population (% of total population) originates from from the United Nations Population Division. World Urbanization Prospects: 2018 Revision, and uses declared Urban populations from declaring countries around the world. The specific definition of urban populations may vary between countries.[10]

Life expectancy at birth, total (years) originates from six sources; (1) United Nations Population Division. World Population Prospects: 2019 Revision, or derived from male and female life expectancy at birth from sources such as: (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various

[8] ""World Development Indicators — DataBank." Accessed December 10, 2022. https://databank.worldbank.org/source/world-development-indicators."

[9] Ibid.

[10] Ibid.

years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme. The data was then compiled over a five year periods to extrapolate life expectancy.[11]

Wiener's definition of **causality** will be used,[12] which dictates that one variable (or time series) could be called 'causal' to another if the ability to predict the second variable is improved by incorporating information about the first. In this definition, causal relationships have two key properties: temporal precedence, where the cause must precede the effect, and physical influence, where changing the cause must change the effect.

Granger causality is a regression-based interpretation of Wiener's definition of causality which is econometric in origin. Given two time series X_t and Y_t, with an auto-regressive model of order p (often called the restricted model) containing the history of X_t to predict the next value with error term $\hat{\epsilon}_t$ and an auto-regressive model similar to the restricted model but also containing the history of Y_t (called the unrestricted model), the Granger causality can be found using an F-test on the two models.[13]

Transfer entropy is an information theoretic-based interpretation of Wiener's definition of causality.[14] Given a discrete random variable X with

[11] ""World Development Indicators — DataBank." Accessed December 10, 2022. https://databank.worldbank.org/source/world-development-indicators."

[12] Norbert Wiener. "Nonlinear Prediction and Dynamics". In: *Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability, Volume 3: Contributions to Astronomy and Physics* 3.3 (Jan. 1956), pp. 247–253. URL: https://projecteuclid.org/ebooks/berkeley-symposium-on-mathematical-statistics-and-probability/Proceedings-of-the-Third-Berkeley-Symposium-on-Mathematical-Statistics-and/chapter/Nonlinear-Prediction-and-Dynamics/bsmsp/1200502197 (visited on 12/09/2022); Steven L. Bressler and Anil K. Seth. "Wiener-Granger causality: a well established methodology". eng. In: *NeuroImage* 58.2 (Sept. 2011), pp. 323–329. ISSN: 1095-9572. DOI: 10.1016/j.neuroimage.2010.02.059.

[13] Bressler and Seth, "Wiener-Granger causality".

[14] Terry Bossomaier et al. "Transfer Entropy". en. In: *An Introduction to Transfer*

possible outcomes $x_1, \ldots, x_n$, which occur with probability $P(x_1), \ldots, P(x_n)$, the entropy of X is formally defined as:

$$H(X) = -\sum_{i=1}^{n} P(x_i) \log(P(x_i))$$

The mutual entropy of two random variables X and Y given by $H(X, Y)$, while $H(X|Y)$ is the uncertainty remaining about X given that we have the information from Y. The transfer entropy from process X to process Y, $T_{X \to Y}$, is the amount of uncertainty reduced in future values of Y by knowing the past values of X given past values of Y or

$$T_{X \to Y} = H(Y_t | Y_{t-1:t-L}) - H(Y_t | Y_{t-1:t-L}, X_{t-1:t-L})$$

Entropy: Information Flow in Complex Systems. Ed. by Terry Bossomaier et al. Cham: Springer International Publishing, 2016, pp. 65–95. ISBN: 9783319432229. DOI: 10.1007/978-3-319-43222-9_4. URL: https://doi.org/10.1007/978-3-319-43222-9_4 (visited on 12/11/2022).

Chapter 2

Review of Related Literature

This section will cover related papers in order to deepen the theoretical grounding of the paper, while also drawing from definitions, techniques, and conclusions obtained from other studies.

2.1 Summary of Research Agenda

The research agenda is focused on the economic effects of urbanization, as well as its historical, theoretical, and social dimensions. The papers will be divided into three sections: policy issues, theoretical literature, and empirical literature. Policy issues will cover current socio-economic issues and government policy related to urbanization and economic growth over the last few decades. Theoretical literature will cover the various theories and models used to understand and predict the relationship between urbanization and economic growth. Empirical literature will cover past studies on the topic with a similar scope, with an emphasis on the empirical, statistical, and mathematical methods used to analyze data.

2.2 Policy Issues

There has been a long history of both active and passive urbanization policies. Historically it seems as though urbanization has been consistently raising for most of human history given that as agricultural productivity increased the need for people to live where they grew food decreased and thus they naturally migrated to urban areas to specialize in other skills. Historically many

states have tried to encourage or discourage this process. One of the earliest accounts of this occurring was during the Roman Empire and the grain dole known as "Cura Annonae" which imported large amounts grain from the Egypt allowing Rome to become the first city to surpass a million people. This was effective in raising the urban population but began experiencing issues with corruption towards the end of the republic ultimately requiring significant reforms. Moreover when the empire began to collapse and grain shipments stopped the city experienced famine and shrunk to a population of just over 40,000 from its height of over a million.[15] Conversely, one of the first examples of states trying to restrict the movement of people into cities would be the Russian Empire in the aftermath of the black death. Where the state instituted a policy of serfdom to keep rural populations tied to their farms.[16]

In more recent years the drivers of economic growth has revolved around economic planning. For instance many of the mega cities of the present day e.g. Jakarta, Manila, or Mumbai, originate from the remnants of a extractive colonial economy which would bring the resources of the country to the capital and largest trading port for export. Much of the continued urbanization can be attributed to many post colonial governments concentrating their limited resources in these pre-existing regions causing labor migration from

[15]Greg Woolf. "Food, poverty and patronage: the significance of the epigraphy of the Roman alimentary schemes in early imperial Italy". en. In: *Papers of the British School at Rome* 58 (Nov. 1990), pp. 197–228. ISSN: 0068-2462, 2045-239X. DOI: 10.1017/S006824620001165X. URL: https://www.cambridge.org/core/product/identifier/S006824620001165X/type/journal_article (visited on 12/11/2022).

[16]Roger Bartlett. "Serfdom and State Power in Imperial Russia". en. In: *European History Quarterly* 33.1 (Jan. 2003), pp. 29–64. ISSN: 0265-6914, 1461-7110. DOI: 10.1177/0265691403033001638. URL: http://journals.sagepub.com/doi/10.1177/0265691403033001638 (visited on 12/11/2022).

other areas. This has caused much strife in regions that are often far away from these historical ports, as well as accusations of economic favoritism. frequently this development inequality can fuel separatist sentiment from outlying regions.[17]

Another modern phenomenon would be the migration of disaster prone communities to urban areas due to increase calamities caused by climate change. Specifically many low lying communities may choose to uproot their lives and move to urban centers that invest significantly more in adoptive technology such as irrigation that makes them less vulnerable to calamities. States can often encourage this process by subsidizing transportation and resettlement as opposed to the reconstruction of affected communities. Though this is often politically unpopular as those who want to stay would often demand the reconstruction of their local communities.[18]

Alternatively there have also been efforts disperse population over a larger area. One prominent example of this would be the Australia's "Three City Model" which aimed to reduce the centralization of people and industries within Sydney and displace them into surrounding communities. States often complain that excess urbanization can lead to congestion, economic segregation as a by product of housing prices, and the lack of communal green spaces. Critics suggest that economic dispersion harms economic mobility as transportation becomes prohibitive, infrastructure becomes more expense,

[17]Meera Kosambi. "The Colonial City in Its Global Niche". en. In: 25.51 (Dec. 1990). URL: https://www.epw.in/journal/1990/51/review-article-book-reviews/colonial-city-its-global-niche.html (visited on 12/11/2022).

[18]Giovanni Peri and Akira Sasahara. *The Impact of Global Warming on Rural-Urban Migrations: Evidence from Global Big Data*. en. Tech. rep. w25728. Cambridge, MA: National Bureau of Economic Research, Apr. 2019, w25728. DOI: 10.3386/w25728. URL: http://www.nber.org/papers/w25728.pdf (visited on 12/11/2022).

and the cities may not work cohesively.[19]

2.3 Theoretical Literature

There is a vast array of economic literature that describes the relationship between urbanization and economic growth.

One economic theory that links urbanization to economic growth is agglomeration theory. This theory is anchored on the phenomenon wherein development—the paving of roads, the construction of buildings, the emergence of entire cities—tends to occur at or near sites of previous development. In their treatment of agglomeration theory, Duranton and Puga discuss three key mechanisms that incentivize the formation of these so-called 'clusters' of development, namely sharing, matching, and learning.[20]

First, on sharing, Duranton and Puga posit that perhaps the simplest justification for the existence of cities is the "indivisibilities in the provision of certain goods and services". Their central example is that of an ice hockey rink. Many people enjoy the entertainment and recreational value of a rink, but would never choose to or even afford to shoulder the costs of maintaining a miniature one for their own homes. A single large rink, while still expensive for ownership, would enjoy the profits generated by the exclusive patronage of hundreds or even thousands of hockey enthusiasts within the city. In essence,

[19] *Three Cities — Greater Cities Commission*. URL: https://greatercities.au/content/three-cities (visited on 12/11/2022).

[20] Gilles Duranton and Diego Puga. "Chapter 48 - Micro-Foundations of Urban Agglomeration Economies". In: *Cities and Geography*. Ed. by J. Vernon Henderson and Jacques-François Thisse. Vol. 4. Handbook of Regional and Urban Economics. ISSN: 1574-0080. Elsevier, 2004, pp. 2063–2117. DOI: https://doi.org/10.1016/S1574-0080(04)80005-1. URL: https://www.sciencedirect.com/science/article/pii/S1574008004800051.

cities provide an ecosystem for these sizable indivisible goods and facilities, from malls, to hospitals, to banks, to exist and even thrive.

Second, regarding matching, Duranton and Puga discuss the advantages cities provide in "matching" workers to job positions. They present an intuitive benefit in that "an increase in the number of agents trying to match improves the chances of matching". The logic is simple: the density and diversity of businesses in cities provides both volume and variety in the work opportunities available to the average laborer. Conversely, the large populations of cities provides businesses with swathes of laborers with varied skill sets and skill levels, thus granting them the human resources needed to expand or become more economically productive.

Last, in terms of learning (e.g. schooling, training, research, etc.), the crux of the economic advantage of cities lies in their ability to greatly facilitate learning through the large populations residing in them. Durant and Puga state that essentially, cities are justified in their existence by the learning opportunities they provide. The multiplicity of businesses promotes knowledge transfer between them, ensuring that different firms employ the most effective processes and technologies in the provision of their goods and services. Individuals also benefit from the level of technical expertise they can access through formal education and job training.

2.4 Empirical Literature

Like with theory, much study has been done in the way of historical and econometric analysis on the positive relationship between urbanization and economic development. Shaban et al. present one such study, in their in-

vestigation of the causality between the two demonstrated in the economic history of Indian states.[21]

In their methodology, Shaban et al. tested for causality between per capita income and the urbanization rate of 15 major Indian states. Using long-term panel data within the period of 1970 to 2020, they employed the method developed by Konya[22] to test for Granger causality between the two variables of interest. Initial visual analysis of the data indicated a positive co-evolution between urbanization, and secondary and tertiary sector per capita income within these states, but not with primary sector per capita income. Granger causality testing afterwards indicated that the causality between per capita income and urbanization rate was mostly unidirectional, with majority of states demonstrating causality from income to urbanization, but not the converse. Bidirectional causality was observed in only two major Indian states.

Shaban et al. note several key implications from these results. First, it questions the mainstream assumptions that urbanization is not only driven by economic growth, but is also a driver of economic growth itself. Second, moving from the theoretical to the pragmatic, it questions whether policies that focus on rapid urbanization, such as seen in India in the past decades, are truly effective means of arriving at economic prosperity. These results ought

[21] Abdul Shaban, Karima Kourtit, and Peter Nijkamp. "Causality Between Urbanization and Economic Growth: Evidence From the Indian States". In: *Frontiers in Sustainable Cities* 4 (May 2022), p. 901346. ISSN: 2624-9634. DOI: 10.3389/frsc.2022.901346. URL: https://www.frontiersin.org/articles/10.3389/frsc.2022.901346/full (visited on 12/10/2022).

[22] László Kónya. "Exports and growth: Granger causality analysis on OECD countries with a panel data approach". en. In: *Economic Modelling* 23.6 (Dec. 2006), pp. 978–992. ISSN: 02649993. DOI: 10.1016/j.econmod.2006.04.008. URL: https://linkinghub.elsevier.com/retrieve/pii/S0264999306000496 (visited on 12/11/2022).

to be taken note of in conducting and interpreting the Granger causality tests for this study.

Chapter 3

Methodology

This section will detail the approach, theoretical underpinnings, and methods used to gather and analyze data about urbanization and economic growth.

3.1 Hypothesis

The hypothesis of this study is that both urbanization and economic growth exert positive causal influence on one another, where urbanization causes economic growth and economic growth causes urbanization.

3.2 Theoretical Framework

From the brief discuss of theoretical and empirical economic literature, we expect there to be a bidirectional causal relationship between urbanization and economic growth. While the specific mechanisms motivate this relationship—if it were to arise—will not be investigated in our methodology, there are several reasons to believe that a bidirectional causality between the two exists. Borrowing from agglomeration theory,[23] urbanized areas allow for the development of sizable indivisible goods services that contribute to economic growth, which in turn creates more prosperous cities to house these indivisibilities. Cities also foster productive labor ecosystems wherein workers and job positions are more effectively matched, spurring business growth and subsequent job production. Lastly, these urban areas provide hubs for information and technology to be more efficiently learned by both firms and

[23]Duranton and Puga, "Chapter 48 - Micro-Foundations of Urban Agglomeration Economies".

individuals, thus increasing both their economic output and their ability to generate new knowledge for future learning.

Empirical results from India's economic history,[24] however, suggest perhaps that the direction of causality between urbanization and economic growth only strongly exists from the latter to the former. As such, while a bidirectional result is still the working framework, results that show greater support for unidirectional causality do not fall out of the realm of expectation.

3.3 Data Model

Two data models will be employed in this study, as two methods to extract causality will be used. The first data model used is Granger causality, with restricted model and unrestricted model respectively:

$$X_t = c + a_1 x_{t-1} + a_2 x_{t-2} + \cdots + a_p x_{t-p} + \hat{\epsilon}_t \tag{3.3.0.1}$$

$$X_t = c + a_1 x_{t-1} + a_2 x_{t-2} + \cdots + a_p x_{t-p} + b_1 y_{t-1} + \ldots + b_p y_{t-p} + \epsilon_t \tag{3.3.0.2}$$

where X and Y are time series data of urbanization (% of population in urban areas) and a selected economic indicator (tests will be run both ways with one as X and the other as Y), with both models as auto-regressive models of order p, with normal error term ϵ, and after some differencing

[24] Shaban, Kourtit, and Nijkamp, "Causality Between Urbanization and Economic Growth".

is conducted on the data to correct for stationarity. This was done on lag 1, and implemented using the `grangercausalitytests` function imported from `statsmodels`.

Since the test already returns a p-value as the main result, this is what will be used to verify the significance of the relationship.

The second data model used is transfer entropy from X to Y is given by

$$T_{X \to Y} = H(Y_t | Y_{t-1:t-L}) - H(Y_t | Y_{t-1:t-L}, X_{t-1:t-L}) \tag{3.3.0.3}$$

where X and Y are time series data of urbanization (% of population in urban areas) and a selected economic indicator (tests will be run both ways with one as X and the other as Y), using Shannon entropy as the main formula of entropy, lag 1, probability distribution estimated using the histogram method and discretized using the default 20 gridpoints, and implemented using the `nonlinear_TE` function imported from `PyCausality`.

The significance of results were verified using the `significance` function also imported from `PyCausality`, which reshuffles and resamples the test (with number of shuffles set to 100) to return a p-value and a mean transfer entropy result.

3.4 Data Sources

Data was taken from the World Development Indicators dataset developed by the World Bank, which independently collects data or compiles it from trustworthy secondary sources like the UN or national statistical offices. As mentioned in the definition of terms, GDP per capita PPP-adjusted (cur-

rent international $) from the World Bank's World Development Indicators dataset comes from the gross domestic product per capita expressed in current international dollars, converted by purchasing power parity conversion factor, which originates from the International Comparison Program and the Eurostat-OECD PPP Programme summarized annually.[25] Urban population (% of total population) originates from from the report titled "United Nations Population Division. World Urbanization Prospects: 2018 Revision," and uses declared urban populations from declaring countries around the world.[26]

This was done directly through the World Bank's API, with the country codes and indicator codes selected for the data we want to retrieve. `pandas` and `numpy` were used to wrangle the data, dropping unimportant columns and shortening country and indicator names for convenience. Log-GDP and GDP growth were also calculated in case they were needed. Data was then visualized using `matplotlib` and analyzed using the methods mentioned in the previous sections. This is covered in significantly more detail in the companion Jupyter notebook.

[25] ""World Development Indicators — DataBank." Accessed December 10, 2022. https://databank.worldbank.org/source/world-development-indicators."

[26] Ibid.

Chapter 4

Results and Analysis

This section will cover the test results conducted by the authors as well as the discussion and analysis of the results and their implications for both the hypothesis and broader policy conclusions.

4.1 Results

There is evidence of some strong positive correlation between urbanization and Log GDP per capita in ASEAN states, both generally increasing with one another (Figure 1).

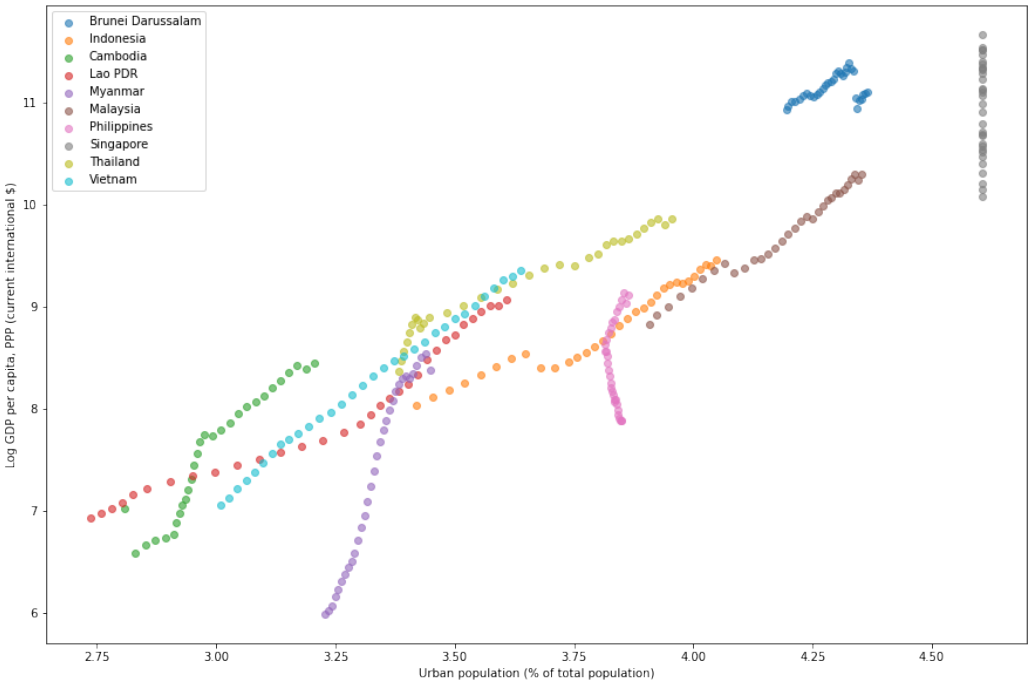

Figure 1: Co-evolution of Urban population and Logged GDP per capita in ASEAN states, 1990-2021

Looking at the evolution of the two variables over time however shows that causation is non-obvious, with countries potentially having some independent autocorrelation that needs to be corrected for (Figures 2 and 3).

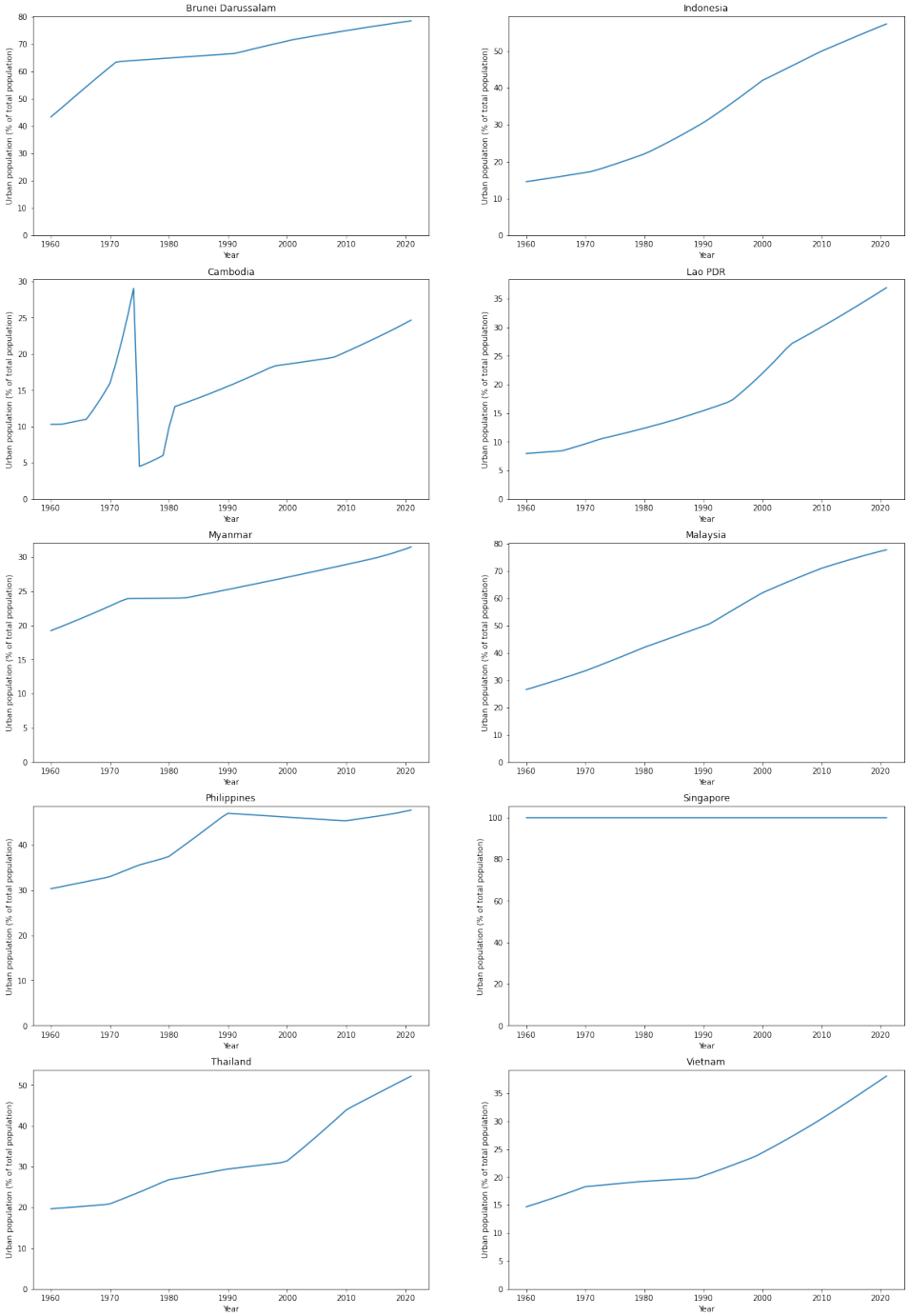

Figure 2: Urban population (%) in ASEAN states from 1990 to 2021

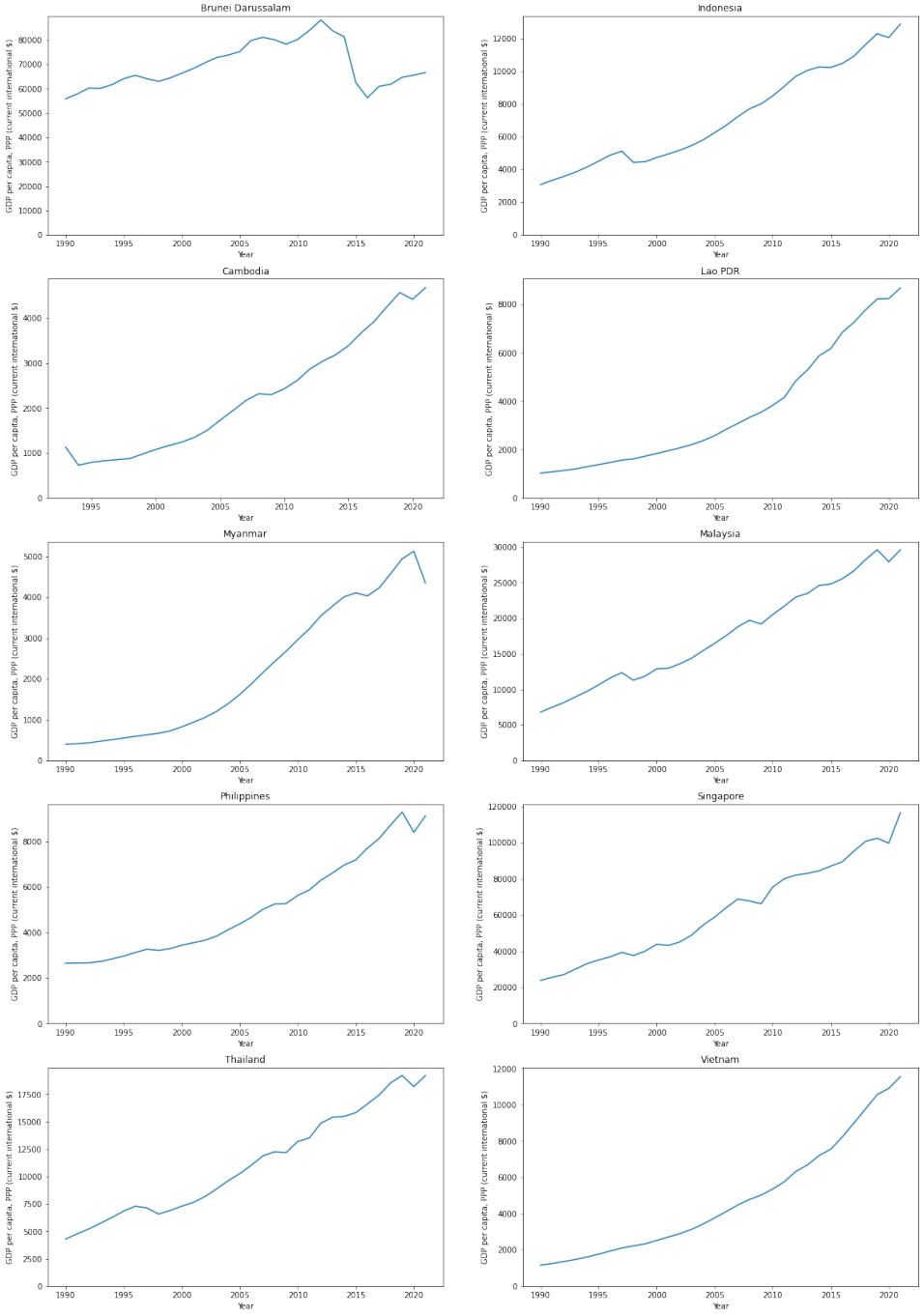

Figure 3: Logged GDP per capita (PPP-adjusted) in ASEAN states from 1990 to 2021

As detailed in the methodology, two-way causality tests to determine the existence and direction of causality between urbanization levels and GDP per capita (PPP-adjusted). Log GDP per capita was used since data suffered from a high range from year to year and from country to country, making results more robust and comparable. The results per country for each and direction are found below:

	Granger		Transfer Entropy	
Country	F-statistic	p-value	Mean	p-value
Brunei Darusallam	0.3189	0.5768	0.0331	0.27
Indonesia	1.2144	0.2798	0.0381	< 0.05
Cambodia	5.3210	< 0.05	0.0338	0.12
Lao PDR	6.0367	< 0.05	0.0358	0.06
Myanmar	6.6279	< 0.05	0.0299	0.9
Malaysia	4.3764	< 0.05	0.0332	0.14
Philippines	3.1450	0.0870	0.0304	< 0.05
Thailand	4.1234	0.0519	0.0342	0.82
Vietnam	0.0553	0.8159	0.0338	0.96

Table 4.1: Urban to Log-GDP

	Granger		Transfer Entropy	
Country	F-statistic	p-value	Mean	p-value
Brunei Darusallam	0.0360	0.8510	0.0363	< 0.05
Indonesia	2.0518	0.1631	0.0369	0.29
Cambodia	0.5607	0.4610	0.0419	< 0.05
Lao PDR	1.5000	0.2309	0.0335	0.98
Myanmar	88.1729	< 0.05	0.0364	0.97
Malaysia	3.3518	0.0778	0.0331	< 0.05
Philippines	143.1358	< 0.05	0.0359	0.92
Thailand	9.5654	< 0.05	0.0330	0.22
Vietnam	27.9173	< 0.05	0.0440	0.98

Table 4.2: Log-GDP to Urban

It should be noted that Singapore was excluded from the analysis because it remains at 100% urbanization for the entire period, and acts as an extreme

outlier. The constant distribution of the data also makes it impossible to discretize probabilities for transfer entropy tests.

4.2 Analysis

Immediately it can be seen that the causality results are inconclusive, with no clear trend emerging for all ASEAN states.

In terms of Granger causality, Brunei and Indonesia have no clear causal relation, Cambodia, Lao PDR, and Malaysia have a significant causal relation for urbanization onto log-GDP, Philippines, Thailand, and Vietnam have a significant causal relation for log-GDP onto urbanization, and Myanmar has a significant bidirectional causal relationship.

In terms of transfer entropy, Indonesia and Philippines have a significant causal relation for urbanization onto log-GDP, Brunei, Cambodia, and Malaysia have a significant causal relation for log-GDP onto urbanization, and the rest have no significant causal relationship.

The rarity of bidirectional causal relationships suggests that in most cases, one effect dominates the other whether it be in terms of temporal precedence or scale of effect. This does not necessarily mean that no bidirectional causal relationship exists at all, but the failure to reject the null hypothesis means that the existence of one effect tends to cause the other not to show up in the data, or overall smothers it. For example, in cases where strong GDP growth enables rural-to-urban migration, increases in urbanization tend not to precede further GDP growth either because GDP growth already correlates with itself or because the effect itself has died down.

In addition, causal relationships for transfer entropy tend not to emerge

when there is a causal relationship for Granger causality. This may be due to the fact that Granger causality only incorporates linear relationships, while transfer entropy captures nonlinear relationships as well, suggesting that when nonlinear trends more strongly emerge, Granger causality returns weak results, and vice-versa for linear trends and transfer entropy.

Lastly, transfer entropy also likely does not return large influences even if some significant ones were found. The interpretation of the mean value of information obtained from adding new information (in bits) is not absolute, and requires a benchmark from the average expectation of bits one can get from a signal in the process space. However, all the results are very close to each other in terms of transfer entropy, which can either indicate that the range of uncertainty minimized is quite small (in that one should consider the max of the range as being very significant) or that there is little causal influence even if significant. Since transfer entropy values are close to each other regardless of if the result is significant (reject null hypothesis that result is random chance) or not (fail to reject null hypothesis) this lends some evidence to the claim that any nonlinear trend is weak if existent at all as the strength of the causality for significant relationships is just as high as if it were by random chance.

Overall, this result casts some doubt on the general assumption that urbanization and GDP per capita are strongly related, at least in ASEAN states. This may caution policy that intends to rapidly urbanize development or encourage rapid urbanization in the name of economic growth, when the causal relationship seems to not be so strong. In terms of implication, this may also moderate our expectations that urbanization will naturally arise

from raising GDP per capita in an area, and may require some explicit state action or intervention presuming that urbanization is the desired outcome.

Chapter 5

Conclusion

In conclusion, the results do not agree with the hypothesis, and in fact contradict it in some cases. No clear causality trend is observed across ASEAN states and across direction in causality, but some exclusivity seems to arise in the small sample size of countries selected. Employing two different methods of causal inference can provide additional insight, noting that if only one method was used, a very different picture of causality and urbanization in ASEAN would have emerged. Overall it seems like the overall gravity of any possible found causality is quite weak, given that transfer entropy results are little stronger than random chance despite high significance, which may also imply that the Granger causality results are also weak given that they would be subsumed by the transfer entropy test.

5.1 Recommendations

In terms of policy, we recommend caution when aiming to encourage economic growth through rapid urbanization, since the causality may not be so clear-cut. In fact, given that many trends are nonlinear, this may have unexpected or even negative results, contrary to conventional economic literature. When aiming to encourage urbanization, similar caution must be taken – both due to the fact that GDP growth does not necessarily create urbanization but also that it may produce different results from what is expected.

In terms of future areas of study, we recommend trying different measures

of urbanization and economic growth, such as a population density measure for urbanization and aggregate GDP for economic growth. This may reveal different insight onto the specific aspects of urbanization and economic growth that get heightened or diminished by a potential causal relationship. In addition, we also recommend trying for data over a longer period of time and potentially for a higher frequency if available. Lastly, other causal inference methods such Bayesian inference may return interesting results when causal relationships are stronger and more heavily felt– as well as trying out different parameters (like lags, time horizons, probability distributions) for transfer entropy and Granger causality.

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