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The Impact of Urban Density on Labour Productivity: Empirical Evidence from Thailand's Major Cities

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Abstract: *This study investigates the relationship between urban density and productivity, specifically wages adjusted for provincial price differences, in four major cities of Thailand: Bangkok, Chiang Mai, Khon Kaen, and Songkla. Utilising the ArcGIS survey of Khon Thai 4.0 data, which measures urban density as the number of inhabitants per grid cell area, we employ the two-stage least squares estimation technique to address endogeneity concerns.*

Our findings demonstrate that higher urban density leads to an 8.9% increase in individual hourly wages at the 5% significance level. This supports the notion that densely populated urban areas foster enhanced productivity through agglomeration economies and knowledge spillovers. Furthermore, we observe the expected impacts of education, age, and gender on wages. Higher education is associated with an 8.2% increase in wages, highlighting its influence on labour productivity. Age exhibits an inverted U-shaped relationship, indicating that experience and skill development lead to higher wages up to a certain threshold. Male workers earn approximately 5.83% more than their female counterparts, revealing a gender wage gap.

Moreover, our analysis reveals contrasting effects of higher urban density on skilled and unskilled workers. Skilled workers experience a significant 15.2% increase in wages, whereas the impact on unskilled workers remains modest at around 1.8%. Additionally, education significantly contributes to higher wages for both skilled and unskilled workers.

This study provides valuable policy implications for promoting labour productivity and addressing urban development challenges in Thailand.

Keywords: rban development; Urban density; Labour productivity; Wage differentials

JEL classification: J24; J31; O15; R11; R12

1. Introduction

It is well known that larger cities increase workers' productivity and wages due to the concentration of firms from different industries in urban areas or urbanisation economies. Specifically, urbanisation economies are economies of scale that are external to both firms and industries in an urban area through learning and superior matching. In developed countries, a doubling of urban density is associated with a 4%–8% increase in local productivity, whereas in developing countries, it can lead to an increase of about 12%–19% (Combes et al., 2010; Grover et al., 2021). However, studies on productivity and cities must deal with the issues of selection bias, as workers with more ability tend to self-select to live in large cities. Most empirical studies deal with this problem by using instrumental variables or worker fixed effects.

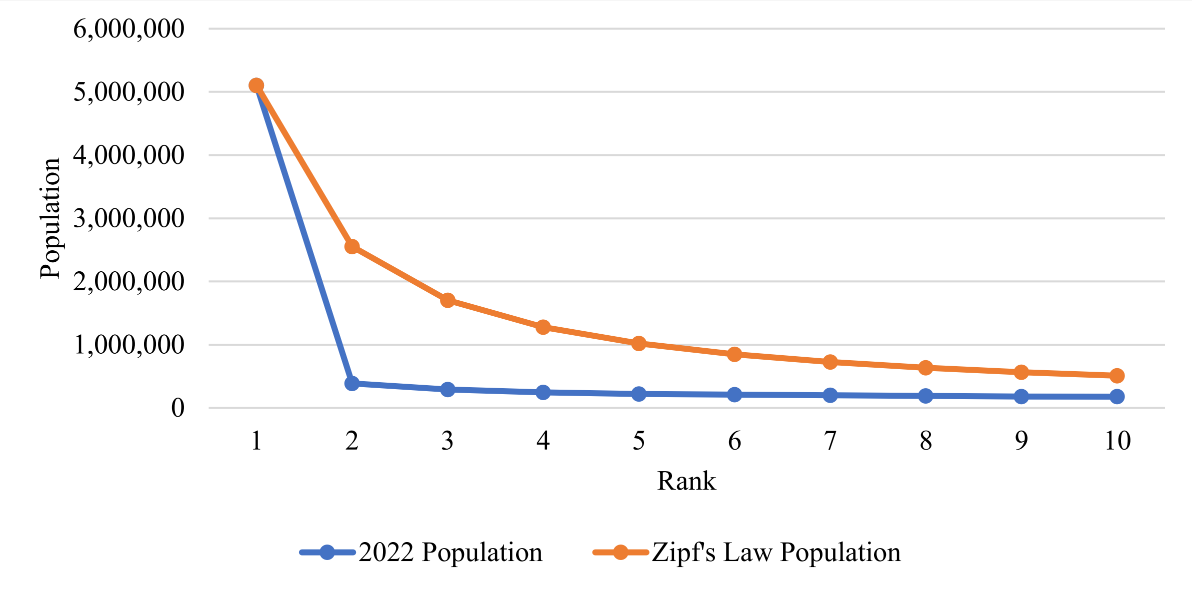
Thailand has faced an imbalance in the rank-size distribution according to Zipf's Law, as illustrated in Figure 1. The graph depicts a significant drop in population between Thailand's largest and second-largest cities, which could imply that the city is attracting individuals or workers due to the benefits of urbanisation and localisation economies.[1] Although urban areas create a better chance of knowledge spillovers amongst workers, overcrowded cities could result in traffic congestion and pollution (Shen et al., 2019). In the case of Thailand, traffic congestion and pollution in Bangkok, a primate city, are a critical issue that national and local governments have put efforts into dealing with. Bangkok is amongst the world's most congested cities, placing 32nd out of 991 cities in 2022 according to the INRIX rankings.[2] It is also amongst the top globally in terms of pollution, ranking 1,247th out of 7,323 cities in 2022, according to IQ Air.[3]

[1] In addition to urbanisation economies, it is well-known that the earnings of workers are higher in cities with a large industry due to the concentration of firms in a specific industry or localisation economies. Localisation economies are economies of scale that are external to the firm but internal to the industry. That is, workers benefit from knowledge spillovers from other workers in the same industry. Workers also become more specialised because a pooled market of workers causes a better searching and matching labour market.

[2] Source: INRIX, 2022, INRIX 2022 Global Traffic Scorecard (https://inrix.com/scorecard/).

[3] Source: IQ Air, 2022, 2022 World Air Quality Report (https://www.iqair.com/th-en/world-most-polluted-countries).

Figure 1: Thailand's Rank Size Distribution Based on Zipf's Law in 2022



Source: World Population Review (https://worldpopulationreview.com/countries/cities/thailand).

This paper aims to investigate the impact of large cities on wage disparities in Thailand's major cities. Specifically, it explores whether urban density enhances labour productivity, which is approximated by wages adjusted for city price differences for Bangkok versus other major cities.

To answer the above questions, we use the dataset from the ArcGIS survey of Khon Thai 4.0. This dataset allows us to analyse employment, skill development, neighbourhood liveability, accessibility to urban amenities, lifestyle, and the socioeconomic status of local people in Bangkok, Chiang Mai, Khon Kaen, and Songkla. Interestingly, instead of being measured as the number of residents in municipal areas, the urban density within this dataset is measured as the number of inhabitants in the grid cells (2x2 square kilometres), analysed by the estimation of utilisation areas in rural and urban areas per grid cell per population with GIS data.

The remainder of this paper is structured as follows: Section 2 provides an overview of the literature on how urban density affects labour productivity. Section 3 details the methodology and data used in the study. Section 4 presents the empirical results and the ensuing discussion. Finally, Section 5 concludes the study by summarising the findings and providing policy recommendations.

2. Literature Review on Urban Density and Labour Productivity

According to Eberts and McMillen (1999), urbanisation economies occur when economic advantages extend beyond individual firms and industries. Marshall (1920) identified three factors that contribute to these economic advantages of agglomeration: a consolidated labour market consisting of specialised skilled workers, technological spillovers, and access to specialised inputs and services. To investigate the impact of city size on wages, a crucial assumption is that in competitive markets, wages reflect the marginal productivity of labour. Additionally, it is assumed that wages are higher in more productive locations (Rosenthal and Strange, 2004). Higher wages are offset by higher productivity, as also suggested by Glaeser and Mare (2001). The wage approach is favoured in such studies due to the availability of wage data.

However, studies examining the relationship between city size and wages must address the issue of selection bias when estimating wage equations. City size can be an endogenous variable because individuals with higher abilities tend to self-select and locate in larger cities, resulting in an ability bias. Therefore, it is necessary to control for unobservable differences amongst individuals that affect wages. If larger cities offer higher wages primarily because they attract more capable workers, a significant portion of the wage premium observed in large cities can be attributed to unobservable skills. To address this concern, some techniques used in studying urban wage premia in large cities include the incorporation of individual fixed effects or lagged explanatory variables in wage regression analysis and the application of instrumental variables through the Two-stage Least Squares (TSLS) method. For instance, Glaeser and Mare (2001) tackle the issue of ability bias by including worker fixed effects in their regression analysis. Their findings indicate that the wage premium in large United States (US) cities ranges from 4.5% to 11%. They also test for selection bias by comparing the wages of long-term residents and recent migrants in the largest cities. The results show a larger urban wage premium for residents, suggesting that the productivity gains are derived from living in the city rather than from the inherent characteristics of the migrants. This indicates that cities contribute to enhancing workers' productivity.

Empirical studies have been conducted to examine the relationship between urban density and productivity, specifically measured by wages. The findings from these studies present a mixed picture. On one hand, several studies, such as Combes et al. (2010), Echeverri-Carroll and Ayala (2009), and Yankow (2006) suggest a positive relationship between labour productivity and urban density. On the other hand, the relationship between urban density and productivity could have an inverted U-shape, as discovered by Shen et al. (2019). This is the result of an overcrowded city, which causes a negative link between productivity and city size through a variety of issues, such as traffic congestion, pollution, and a lack of public resources.

To estimate the effect of urban wage premia on wages in big cities, most research incorporates basic observed individual characteristics, such as education, experience, and job tenure in wage regressions (Morikawa, 2011; Ahrend et al., 2014; Kompa and Witkowska, 2018).

Starting with the education factor, Pereira and Martins (2004) used the supply and demand concept to explain the relationship between education and wages. An increase in education level leads to a rise in the skilled labour supply. As firms and businesses require labour with higher qualifications and skills, a shift in demand occurs, determining differed labour prices through the movement of labour supply and demand. Alsulami (2018), Morikawa (2011), and Wannakrairoj (2013) discovered a positive correlation between education and an individual's wage. Labour with a higher level of education has a higher chance of being hired and receiving on-the-job training and knowledge from firms, leading to an improvement in individual skills and productivity.

Labour's age and work experience can also impact the level of labour productivity. Previous studies, however, came to a variety of conclusions. Lazear (1976) discovered a positive relationship between the number of working hours and wage; whereas Aubert and Crépo (2006) found that labour productivity, as measured by wage, increased until a certain age and then remained stable. Majchrowska and Broniatowska (2018) discovered a positive relationship between wage and employees aged 50+ in the occupations of clerical support workers and managers, which could be attributed to a worker seniority scheme. Regardless, Luong and Hebert (2009) noted that age and work experience tend to correlate with each other because workers gain more experience as age increases. In some studies, age has been used as a proxy for work experience, leading to the exclusion of experience from the model due to collinearity between age and experience. In Wannakrairoj (2013), the Mincerian wage regression model was employed to examine the effects of education and experience on wages in both urban and rural labour markets in Thailand. The findings suggest that education, experience, and wage are positively related, indicating that an extra year of education or experience would lead to an increase in wages. However, in Thailand, an additional year of education is found to have a stronger correlation with workers' wages than an increase in their years of experience.

3. Data and Methodology

Using the Khon Thai 4.0 ArcGIS survey data from Ratanawaraha (2022), this paper investigates the impact of urban density on labour productivity at the individual level in four major cities in Thailand: Bangkok, the capital city; Chiang Mai, a major city in the north; Khon Kaen, a major city in the northeast, and Songkla, a major city in the south. In 2021, the survey covered 1,100 households in Bangkok, 850 households in Chiang Mai, 848 households in Khon Kaen, and 870 households in Songkla. The dataset includes information on respondents' employment, skill development, socioeconomic status, lifestyle, neighbourhood liveability, and accessibility to urban amenities. Table 1 highlights several key questions from the Khon Thai 4.0 ArcGIS survey.

Table 1: Example Questions from the Khon Thai 4.0 ArcGIS Survey

Categories	Questions
Employment and skill development	Work experience
	Wage
	Use of technology
	Number of hours spent on online training for upskilling and reskilling
Socioeconomic status	Education level
	Level of income and expenses
Lifestyle	Household expenses
	Frequency of purchasing goods through online grocery stores, online shopping, and food delivery applications
Neighbourhood liveability and accessibility to urban amenities	Perception of neighbourhood liveability: pollution level, availability of natural resources, quality and presence of business facilities
	Access to urban amenities: public health, school, and transportation

Source: Ratanawaraha (2022).

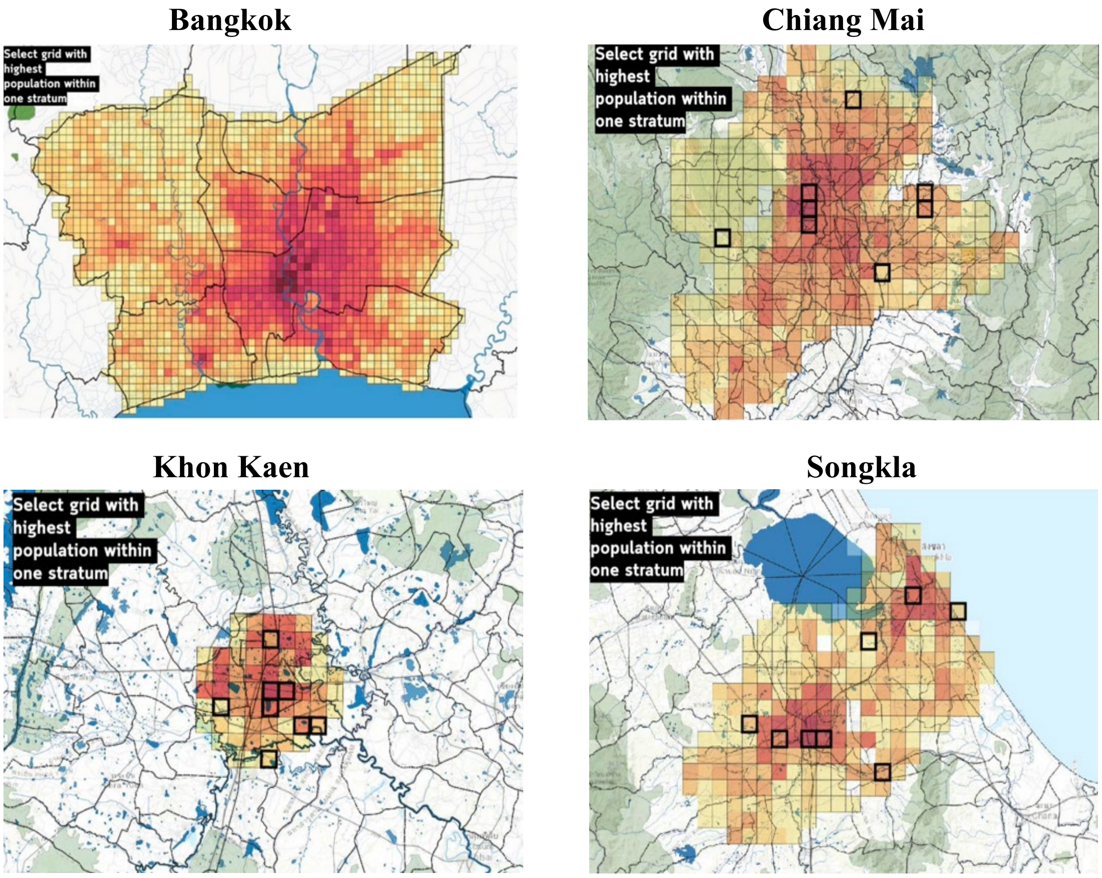
Unlike previous studies that defined urban density in Thailand roughly as the number of registered populations per area at the provincial level, we were able to define it at a more detailed neighbourhood level using this new dataset. As shown in Table 2, each neighbourhood, treated as a grid cell with a dimension of 2x2 square kilometres, was classified into 10 urban categories ranging from metropolitan centres to rural areas with very low density. Figure 2 presents an overview of the urban density maps of the four major cities of Thailand in 2021.

Table 2: Urban Categories of Grid Cells by Density Level

Grid	Population per grid	Definition
1	1–600	Very low level of density in rural areas
2	601–1,200	Low density level in rural areas
3	1,201–2,000	Rural centre
4	2,001–4,000	Edge of the city
5	4,001–6,000	Suburban area
6	6,001–10,000	Moderate density in the urban area
7	10,001–20,000	High density in the urban area
8	20,001–30,000	Urban centre area
9	30,001–40,000	Urban centre area with high density
10	>40,000	Metropolitan centre

Source: Ratanawaraha (2022).

Figure 2: Urban Density Map of Four Major Cities in Thailand, 2021



Source: Ratanawaraha (2022).

Our analysis is based on a sample of 1,462 individuals aged 15 years of above who were employed on a full-time basis in the year 2021. We have constructed an empirical model to examine the relationship between wage premia and urban density, which is represented as follows:

$$log\ (Productivity_{ic}) = \alpha + \beta_1\ Urban\ Density_{ic} + \beta_2\ Education_{ic} + \beta_3\ Age_{ic} + \beta_4\ Age^2_{ic} + \beta_5\ Gender_{ic} + \beta_6\ City_{ic} + u$$

In the equation above, log (productivity) represents the level of labour productivity of each worker (*i*) in city *c*, proxied by the individual hourly wages adjusted for provincial price differences,[4] for Bangkok versus other cities. Urban density is measured by the number of inhabitants in the grid cell (2x2 square kilometres) and is represented as the density degree ranging from the lowest to the highest (1-10). The control variables include basic observed individual characteristics, including education level, age, age-squared, and gender as well as their city of residence.

Table 3 presents the descriptive statistics for the key variables utilised in the study. Regarding the living conditions, the data showed that on average, workers resided in neighbourhoods with moderate urban density, as indicated by an average density level of 6.61 and a standard deviation of 2.22. This scale ranges from 1 (representing a very low density in rural areas) to 10 (indicating a metropolitan centre). Interestingly, both skilled and unskilled labour exhibited similar levels of urban density. Here, workers are classified as skilled workers if they graduated with a vocational certificate level or higher, and unskilled workers if they graduated with upper secondary education or lower or have no formal education.

The average provincial difference adjusted hourly wage earned by workers was 100.23 Thai Baht. Notably, skilled labour had a higher average wage of B116.01, whilst unskilled labour had a lower average wage of B85.62.

The average age of workers in the study was 45.11 years. Skilled labour tended to be slightly younger, with an average age of 40.29 years, whilst unskilled labour had an average age of 49.57 years. In terms of education, workers in the sample had an average education level of 4.22, ranging from 0 to 6. This suggests a mix of both skilled and unskilled labour, with a higher representation of unskilled workers in the sample.

Gender distribution showed relative similarity across the groups, with an average score of 1.57 for all workers. The data also revealed that pollution levels in the workers'

[4] Data on cost of living in each province are from NUMBEO (https://www.numbeo.com/cost-of-living/).

neighbourhoods were relatively consistent. On a scale of 1–5 with 1 being very bad pollution, the average score was 3.54. Additionally, access to business support centres was moderately available to all workers, with an average score of 3.40, measured based on a similar 1–5 scale as pollution.

It is worth noting that the data suggested workers in the sample likely lived in close proximity to their workplaces, as the average commuting time from their residences to their workplaces was approximately 13 minutes.

Table 3: Mean and Standard Deviations of Variables for Samples for Both Skilled and Unskilled Labour

Variable	All	Skilled Labour	Unskilled Labour
Sample size	*1,462*	*703*	*759*
Provincial Difference Adjusted Hourly	100.23	116.01	85.62
Wage (B)	(76.38)	(93.70)	(51.66)
Urban Density (1–10)[1]	6.61	6.57	6.65
	(2.22)	(2.03)	(2.39)
Age	45.11	40.29	49.57
	(13.74)	(12.04)	(13.71)
Education Level (0–6)[2]	4.22	5.69	2.86
	(1.61)	(0.46)	(0.95)
Gender (1–3)[3]	1.57	1.57	1.58
	(0.50)	(0.50)	(0.50)
City[4]	2.37	2.59	2.17
	(1.18)	(1.16)	(1.16)
Pollution[5]	3.54	3.55	3.53
	(0.86)	(0.86)	(0.86)
Access to business support centres (1–5)[6]	3.40	3.42	3.39
	(0.92)	(0.96)	(0.89)

Note: Standard errors are in parentheses.

[1] Urban density level: very low level of density in rural areas (level 1); …; metropolitan areas (level 10).

[2] Levels of education include: no education (level 0); early childhood education (level 1); primary education (level 2); lower secondary education (level 3); upper secondary education (level 4); vocational certificate and post-secondary non-tertiary education (level 5); bachelor's level or higher (level 6).

[3] Gender includes: male (1); female (2); others (3).

[4] Cities include: Bangkok (1); Chiang Mai (2); Khon Kaen (3); and Songkla (4).

[5] Pollution includes: very bad (1); …; very good (5).

[6] Access to business support centre includes: very bad (1); …; very good (5).

Source: ArcGIS Survey of Khon Thai 4.0

4. Empirical Results and Discussion

4.1. Ordinary Least Squares (OLS) Estimation Results

In this section, we present and discuss the empirical findings regarding the relationship between urban density and labour productivity, which is measured by wages adjusted for provincial price differences in 2021. In our baseline estimation, we employ ordinary least squares (OLS) regression analysis whilst considering heteroscedasticity in the error term. This is done to address the potential correlation between observations, which may differ amongst the cities.

The results reveal a significant association between individual hourly wages and their level of urban density at the 1% significance level. Specifically, our findings indicate that higher urban density is associated with a 1.93% increase in individual hourly wages. This may be due to the advantages of better matching between workers and firms in urban areas compared to rural areas. In particular, workers residing in densely populated urban areas can explore new job opportunities that match their skills and specialisation areas. Furthermore, firms located in urban areas with high density can choose workers from a larger pool of labour market participants who meet their needs or job qualifications the most, and then pay them competitive rates to hire and retain them.

Additionally, the observed individual characteristics exhibit the expected signs and magnitudes, and they are statistically significant at the 1% level. For instance, on average, a male worker who is well-educated and has work experience can expect to earn higher hourly wages compared to other full-time male and female workers.

However, it is crucial to acknowledge the potential presence of endogeneity issues, as emphasised in the existing literature (Echeverri-Carroll and Ayala, 2009; Morikawa, 2011). In the presence of endogeneity, OLS estimation may produce biased and inconsistent parameter estimates, leading to misleading hypothesis tests. Consequently, the next subsection will explore the potential instrumental variables (IVs) that can address the problem of ability bias in large cities.

Table 4: Baseline Results of the Ordinary Least Squares (OLS) Estimation

Variables	OLS Baseline Model
Urban Density	0.0193***
	(0.0067)
Age	0.0273***
	(0.0064)
Age Squared	-0.0003***
	(0.0001)
Education Level	0.0869***
	(0.0105)
Gender - Female	-0.0631**
	(0.0291)
Gender - Others	-0.1665
	(0.1348)
Control Variable: City	Yes
Constant	3.1402***
	(0.1676)
Observations	1,473
R-squared	0.1198

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Source: Authors.

4.2. Two-stage Least Squares (TSLS) Estimation Results

To address the issue of endogeneity in this cross-sectional data study, we employ the two-stage least squares (TSLS) estimation technique. This method requires the instrumental variable to be correlated with the independent variable but uncorrelated with the error term. In our study, the predicted endogenous variable is urban density because workers with higher abilities tend to choose to live in larger cities to find better job opportunities that match their expertise – job opportunities that are not available in rural or less dense areas.

In this study, we employ two instrumental variables, namely individual perception of pollution and individual perception of the business-supporting infrastructure in their neighbourhood area. The first instrumental variable in this study is individual perception of pollution in their residential area, assessed using a Likert scale ranging from 1 to 5, with 1 representing a high level of pollution and 5 indicating a low level of pollution. The relationship between individual perception of pollution and urban density is strongly negative at the 1% significance level, suggesting that workers tend to perceive higher levels of pollution in urban areas compared to rural areas.

The second instrumental variable used in this study is the presence of facilities that foster business activity, such as research institutes or start-up incubators, within the area. This variable is assessed on a scale from 1 to 5, with 5 indicating the highest level of abundance and support. The relationship between individual perception of pollution and urban density is strongly positive at the 1% significance level. It indicates that innovation and business facilities tend to be in areas characterised by high urban densities. This finding is supported by the research of Madaleno et al. (2022), who found that knowledge spillovers exhibit substantial distance decay for professional services, tech, and creative industries, supporting the idea that the presence of innovation and business facilities are correlated with urban density. Moreover, the presence of organisations facilitating business and innovation activities should not be correlated with individual wages. As public transportation networks expand and improve, people are increasingly choosing to move to areas of high urban density. In the same vein, the World Bank describes a suburbanisation phenomenon whereby there is a spatial concentration of jobs alongside the dispersion of homes in many countries spanning the developmental spectrum.[5]

To address the issue of endogeneity, we employed TSLS estimation, and the results reveal that the impacts of all variables that were statistically significant in the OLS baseline model remain qualitatively unchanged, as presented in Table 5. Notably, there is a positive relationship between urban density and labour productivity, which is measured by provincial price difference-adjusted wages. This indicates that higher urban density generally has a beneficial effect on wages, estimated to be approximately 8.9% at the 5% significance level.

The larger coefficient obtained from the TSLS model, in comparison to the OLS model, can be attributed to the consideration of the local average treatment effect (LATE). Unlike OLS estimation, which estimates the average treatment effect (ATE) for the entire population, instrumental variables (IV) estimation focuses on the LATE. The IV approach identifies the effect of an instrument on a specific subgroup of individuals who exhibit a stronger response to the treatment (in this case, urban density) compared to the average response. In simpler terms, the IV estimate represents the impact of increasing urban density solely for the population influenced by the instrument, whilst the OLS estimate describes the average earnings difference for individuals with varying levels of urban density.

Due to the presence of heterogeneity within the studied population, IV estimates generally tend to be larger than OLS estimates. The IV approach captures the specific effect on the subgroup affected by the instrument, reflecting a potentially larger treatment effect

[5] https://blogs.worldbank.org/sustainablecities/rethinking-density-build-cities-future

compared to the average effect estimated by OLS, which encompasses the entire population (Card, 1999; 2001).

Regarding other control variables on unobservable differences amongst individuals, including education, age, and age squared, all are statistically significant at the 1% level and have coefficients of a similar magnitude as in the OLS baseline model. However, the gender variable indicating that female workers get lower wages than male workers is statistically significant at the 10% level, although not at the 5% level. On average, a male worker who is well-educated and has work experience can expect to earn higher hourly wages compared to other full-time male and female workers.

To ensure the validity of the TSLS estimation results with robust standard errors, we employ Wooldridge's robust score test and regression-based tests to examine whether urban density is an exogenous variable. Additionally, we conduct Wooldridge's robust score test to assess the overidentifying restrictions in our model. By conducting these tests in the subsequent sub-sections, we aim to verify the robustness and validity of our TSLS estimation results whilst accounting for potential biases and addressing concerns related to endogeneity and instrument validity.

Table 5: OLS and TSLS Wage Regression Results

Explanatory Variables	**(I) OLS**	**(II) TSLS**
Urban Density	0.0193***	0.0892**
	(0.0067)	(0.0387)
Age	0.0273***	0.0285***
	(0.0064)	(0.0063)
Age Squared	-0.0003***	-0.0003***
	(0.0001)	(0.0001)
Education Level	0.0869***	0.0817***
	(0.0105)	(0.0107)
Gender - Female	-0.0631**	-0.0583*
	(0.0291)	(0.0300)
Gender - Others	-0.1665	-0.1930
	(0.1348)	(0.2549)
City - Control Variable	Yes	Yes
Constant	3.1402***	2.5820***
	(0.1676)	(0.3399)
Observations	1,473	1,462
R-squared	0.1198	0.0598

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Source: Authors.

4.2.1. Endogeneity tests

To ensure the validity of our findings, we performed endogeneity tests to determine whether urban density should be treated as an exogenous or endogenous variable. Wooldridge's heteroskedasticity-robust score test and regression-based test were employed for this purpose, and the results are presented in Table 6. The test results indicate that, at the 5% significance level, we do not reject the null hypothesis of urban density being exogenous. However, at the 10% significance level, we lack sufficient evidence to conclude exogeneity. Based on these findings, we lean towards treating urban density as endogenous. It is important to note that even if the urban density variable is indeed exogenous, the consistency of our TSLS estimates remains intact. However, if instead, urban density is endogenous, OLS estimates would be inconsistent.

Table 6: Tests of Endogeneity

Tests of Endogeneity	Statistic	P-value
Wooldridge's Robust Score Test	3.58322	0.0584
Regression-based Tests	3.565	0.0592

Source: Authors.

4.2.2. Instrument strength test

To assess the effectiveness of our instruments, we conducted a test to examine the joint significance of the coefficients based on the summary statistics of the first-stage regression. Table 7 demonstrates that our proposed instrumental variables are both relevant and valid, as indicated by the rejection of the null hypothesis of weak instruments. The F-statistic of 33.43 is significant at any significance level and surpasses the critical value of 10, as suggested by Stock, Wright, and Yogo (2002) when there is one endogenous regressor. This implies that the joint inclusion of our additional instruments significantly contributes to explaining urban density.

Table 7: Test for the Joint Significance Level

Variable	Robust F-statistic	Prob > F
Urban Density	33.4345	0.0000

Source*:* Authors.

4.2.3. Overidentification Test

To ensure the validity of the instruments and the exclusion restriction, we conducted Wooldridge’s robust score test for overidentifying restrictions. The joint null hypothesis of these tests is that the instruments used in the analysis are valid or uncorrelated with the error term and that the excluded instruments are correctly excluded from the structural equation. In this study, we employed Wooldridge's robust score test of overidentifying restrictions.

As shown in Table 8, the test statistics for both tests are not significant at any level. These findings indicate that either there was no correlation between our instruments and the error term, or the structural equation was not incorrectly specified. Therefore, our instruments are valid, and our structural model is specified correctly.

Table 8: Test of Overidentifying Restrictions

Test of Overidentifying Restrictions	Statistic	P-value
Wooldridge's robust score test	0.34302	0.5581

Source: Authors.

4.2.4. Checking for robustness: skilled workers vs unskilled workers

To ensure the robustness of our model, we conducted additional analysis to examine the influence of urban density on labour productivity for both skilled and unskilled workers. Following the approach outlined in previous sections, we estimated separate models using OLS and TSLS methods. We carefully addressed the issue of endogeneity related to urban density and assessed the validity of instrumental variables for each worker group. Based on the test results, we selected the appropriate estimation method, employing TSLS for skilled workers and OLS for unskilled workers. The estimation results for both groups are presented in Table 9.

Table 9 reveals interesting findings regarding the impact of urban density on wages for skilled and unskilled workers. Notably, we found a significant positive effect of higher urban density on individual hourly wages for skilled workers, with an increase of approximately 15.18% This can be attributed to the advantages that urban areas offer skilled workers, including access to specialised inputs, a concentrated labour market of specialised workers, and technological spillovers, as theorised by Marshall (1920). On the other hand, the impact of urban density on wages for unskilled workers was relatively modest, at around 1.8%, indicating that they do not benefit as significantly from urbanisation economies compared to their skilled counterparts.

Moreover, a higher level of education exhibited a substantial positive effect on individual hourly wages for both skilled and unskilled workers. Skilled workers experienced a significant increase of approximately 29.2% in wages with higher education, whilst the increase for unskilled workers was approximately 4.9%.

In terms of age, we found that it had a positive association with labour productivity for both skilled and unskilled workers, albeit at diminishing rates. This implies that as workers age, their productivity increases, although the rate of increase gradually declines over time.

Regarding gender differences, we did not observe a significant impact on wage disparities amongst skilled workers. However, for unskilled workers, non-male individuals tended to receive lower wages compared to their male counterparts. This discrepancy may be attributed to the physical strength often required for unskilled jobs, which can place non-male workers at a disadvantage.

Table 9: Estimation Results for Wages of Skilled and Unskilled Workers

Variables	Skilled Labour	Unskilled Labour
Urban Density	0.1518**	0.0183**
	(0.0667)	(0.0089)
Age	0.0450***	0.0198**
	(0.0133)	(0.0086)
Age squared	-0.0005***	-0.0002**
	(0.0002)	(0.0001)
Education Level	0.2922***	0.0486**
	(0.0496)	(0.0229)
Gender - Female	-0.0480	-0.0753*
	(0.0484)	(0.0397)
Gender - Others	-0.3567	-0.1690**
	(0.2574)	(0.0593)
Control Variable - City	Yes	Yes
Endogeneity Test		
Robust Score test statistic	4.1901**	
[P-value]	(0.0407)	
Regression-based test statistic	4.2503**	
[P-value]	(0.0396)	
Instrument Strength Test		
Robust F-Statistic	13.8027***	
[P-value]	(0.0000)	
Overidentification Test		
Wooldridge's robust score test	0.0057***	
[P-value]	(0.9401)	
Constant	0.5531	3.4893***
	(0.7038)	(0.2493)
Observations	703	766
R-squared		0.0663

Note: Robust Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Source: Authors.

5. Conclusion and Policy Recommendations

5.1. Conclusion

In this study, we examine the relationship between urban density and labour productivity proxied by individual hourly wages adjusted for price differences in Thailand's major cities of Bangkok, Chiang Mai, Kon Kaen and Songkla. The use of the ArcGIS Survey of the Khon Thai 4.0 dataset allows for a more precise and reliable measurement of urban density, which is calculated as the ratio of population per grid cell (2x2 square kilometres) of building coverage and floor area. This is a more accurate indicator than the traditional proxy of urban density, which is measured as the ratio of population per area at the provincial level.

Although the OLS estimation provides significant results, it is subject to bias and inconsistency. Therefore, to address the endogeneity issue, the TSLS estimation technique is employed, utilising instrumental variables related to individual perception of pollution and individual perception of business-supporting infrastructure in their respective neighbourhoods. The TSLS estimation results confirm the positive association between urban density and wages, reinforcing the findings from the OLS estimation.

Based on the TSLS empirical analysis conducted in this study, several key findings emerge regarding the relationship between urban density and individual hourly wages, adjusted for price differences, in Thailand's major cities. The results indicate a significant positive association between urban density and individual hourly wages, with higher urban density resulting in an approximately 8.9% increase in wages at the 5% significance level. This suggests that densely populated urban areas, with their concentration of firms and diverse job opportunities, contribute to enhancing workers' productivity. These findings align with the concept of urbanisation economies, highlighting the advantages of agglomeration in urban settings.

Furthermore, the control variables, including education level, age, and gender, demonstrate the expected impact on wages. On average, male workers with higher education levels and older individuals tend to have higher wages. Specifically, higher education is significantly associated with an 8.2% increase in wages. This finding underscores the importance of higher education as a critical factor influencing labour productivity in Thailand. Higher education equips individuals with cognitive skills development, enabling them to deepen their understanding of their field and adapt to new technological changes, thereby enhancing their ability to learn and work effectively.

In addition, the estimation results reveal an inverted U-shaped relationship between age and wages, indicating that the impact of age on wages increases at a decreasing rate. Age is found to increase wages by 2.85%, with a decreasing rate of 0.03%. This suggests that workers gain experience and skill development, such as soft skills, communication skills, and problem-solving skills, leading to increased productivity levels as they grow older. However, beyond a certain point, older workers may experience diminishing returns in terms of labour productivity due to factors such as physical fitness or the ability to adapt to rapidly changing technology.

Furthermore, male workers tend to earn higher wages compared to female workers, with a statistically significant difference of approximately 5.83% at the 10% significance level. This gender wage gap highlights the presence of gender-based disparities in the labour market, indicating the need for targeted policies and interventions to promote gender equality and address the underlying factors contributing to wage differences.

To ensure the robustness of our model, we conducted additional analysis to examine the impact of urban density on wages for skilled and unskilled workers separately. The results reveal interesting patterns. Specifically, we found a significant positive effect of higher urban density on individual hourly wages for skilled workers, with an increase of approximately 15.18%. In contrast, the impact of urban density on wages for unskilled workers was relatively modest, at around 1.8%. These findings suggest that the concentration of skilled job opportunities in densely populated urban areas provides greater economic benefits to skilled workers compared to their unskilled counterparts.

Moreover, the level of education demonstrated a substantial positive effect on individual hourly wages, particularly for skilled workers. Skilled workers with a higher level of education experienced an approximate 29.2% increase in wages, indicating the importance of educational attainment in enhancing their earning potential. On the other hand, the increase in wages for unskilled workers with a higher level of education was approximately 4.9%. These results highlight the critical role of education in improving labour market outcomes, particularly for skilled workers.

Regarding gender differences, our analysis reveals that there is no significant gender difference in the impact of urban density on wages for skilled workers. However, for unskilled workers, non-male individuals tended to receive lower wages compared to their male counterparts. This discrepancy can be attributed to the nature of unskilled work, which often involves labour-intensive tasks that require physical strength, potentially leading to gender-based wage disparities.

5.2. Policy Recommendations

Based on the findings of this study, the following policy recommendations are proposed to promote labour productivity and address the challenges associated with urban density in Thailand's major cities:

(1) City planning should allow for high-density development to benefit from economies of agglomeration. Specifically, the use of mass transit, particularly the rail system, should be subsidised to reduce road congestion and attract more talent so that workers in urban areas can benefit more from the spillover effect.

(2) Facilities for public safety and amenities should be provided to accommodate denser cities to ensure a high quality of life for residents.

(3) The national government should allocate increased budgets for non-metropolitan areas to achieve a more balanced rank-size distribution of cities. Targeted investments in infrastructure, education, and business development, such as public transportation, road networks, digital technologies, and knowledge and business-supporting facilities, will enhance efficient transportation, connectivity, knowledge sharing, and the emergence of new ideas and technologies.

(4) A better monitoring system should be implemented to reduce school dropout rates. Scholarship or financial assistance should also be provided to poor families to support education. Currently, Thailand still faces the problem of having a high rate of NEET (not in education, employment, or training) youth. NEET youth (aged 15–24) accounted for 13.38% of the total number of youths in Thailand in 2022.

(5) The government should prioritise investments in quality education and vocational training, as well as skill development programmes to help targeted groups, such as the poor and women, acquire the necessary skills and qualifications to match the demands of job markets.

By implementing these policy recommendations, Thailand can foster sustainable urban development, enhance labour productivity, and ensure inclusive growth. These measures will contribute to creating vibrant and competitive cities whilst effectively addressing the challenges associated with urban density.

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