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Abstract

Housing price escalations are not innocuous. In Singapore context, falling average propensity to consume and falling fertility rate are two such negative effects already documented. In this exercise we examine another unexplored effect, the impact on income inequality in Singapore. Housing price escalations involve a substantial income re-distribution away from home buyers for owner occupation to property developers, rental property owners and financiers. This effect is largely reflected in non-labour earnings. Even with household labour income data we have, we find a statistically significant small effect of rising private property prices on income inequality measured by the percentile ratio P90/P10. Unexpectedly the most robust variable that explains this income ratio turns out to be the share of resident graduates in total employment. This variable shows an inverted U effect on income inequality and indicates that until this share rises to about 25%, household labour income inequality is going to increase. Similar inverted U effect is found with a productivity ratio variable that was used to measure the effect of globalization.

Key Words: Household labour income, income percentile ratios, private housing price, higher education, globalization

JEL Classification: R21, D31.

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1. Introduction

Rising income inequality has been a global phenomenon and Singapore is not an exception. Singapore's income Gini coefficient among employed resident[1] households, for example, increased from 0.457 in 2003 to 0.478 in 2012 and then dropped to 0.463 in 2013. After accounting for government transfers and taxes, however, the Gini coefficient increased only mildly from 0.423 in 2003 to 0.434 in 2012 before dropping to 0.413 in 2013 (DOS, 2014). The widening income gap in many developed countries is often attributed to global forces. Nevertheless, some country specific causes are likely to set the countries apart in terms inequality levels and trends. Understanding these causes would help in policy formulations.

One factor that has contributed to a wider income gap in Singapore is the dual nature of Singapore's labour market openness. At the top end, competition for international talents drives up the earnings of top earners. At the lower end the unlimited supply of low-skilled workers from the region keeps low-end wages stagnating. Options available for addressing the income gap caused by the high-skilled low-skilled divide are very limited. Excessively restricting foreign labour without offsetting gains in productivity is counter-productive. Productivity improvements, however, have been a long drawn process.

There is another unsuspected force that may have been contributing to the widening income gap in Singapore; that is, the escalation of residential property prices. Between 1975 and 2013 the median price of private residential properties increased on average by 10% per year while the CPI inflation rate was 2.3% per year. While trending upward in general, the country experienced four episodes of property price escalations since independence in 1965 (1979-81, 1987-96, 2006-07, and 2010-12). During these episodes annual price increases peaked at 102% in 1981Q1, 47% in 1994Q3, 31% in 2007Q4 and 38% in 2010Q2.

In previous studies we have observed that unaffordable increases in residential property prices constrain household consumption expenditures leading to a downward trend in the average propensity to consume and lower the fertility rate (Abeysinghe and Choy, 2004; Yi and Zhang, 2010; Abeysinghe, 2011; Toh, 2011). To this list we may have to add the widening income gap as another negative impact of escalating property prices. Although increasing property prices appear to increase housing wealth it is not so in Singapore because of the lack of monetizing opportunities unless one chooses to downgrade (or emigrate). A question that arises then is who benefits from rising property prices. Increasing property prices leads to income redistribution away from buyers

[1] Resident refers to Singapore citizens and permanent residents.

(including up-graders) for owner occupation to developers, rental property owners, financiers and business professionals. Therefore, benefits of rising property prices are realized only at the top end of the income ladder. It is this re-distributional aspect of rising property prices that could add to the widening income gaps.

The main objective of this exercise is to examine whether residential property prices have any impact on Singapore's income inequality after accounting for other determinants. Although the Gini coefficient is commonly used to measure income inequality, in Singapore this measure is available only annually since 2002. Given the data constraints, we measure income inequality primarily by the household labour income percentile ratio (P90/P10) quarterly since 1981. Although the re-distributional effects of rising housing prices are not fully reflected in this ratio since it does not account for non-labour earnings,[2] it seems to capture the housing price dynamics to some extent. In the search for other determinants that could explain this labour income ratio, we also stumbled upon an interesting inverted U shape in the effect of higher education on income inequality. Although a similar inverted U effect is observed for a productivity ratio that we use to capture both globalization and foreign worker effect, this effect is not as strong as the education effect in explaining labour income inequality.

2. Causes of income inequality

The literature on income inequality is vast and we do not intend to provide a comprehensive survey here. We reviewed some recent studies only for the purpose of determining most suitable control variables in our regression of income inequality on housing price in Singapore.

One most commonly cited cause of rising income inequality in the developed world is globalization. Globalization is often understood as the phenomenon of increased international integration, characterized by the movement of people, technology, commodities and ideas across national boundaries. While many studies have looked at the income distribution effect of globalization, there are variations in the measure used to capture globalization itself. It should be noted that globalization is a complex phenomenon that realizes through many different channels – economic, social and technological, just to name a few. Coupled with the problem of data availability, existing

[2] Note that even the Gini coefficient is computed using the labour incomes in Singapore.

studies have leveraged on a few more prominent measures of globalization. Helpman, Itskhoki, and Redding (2010) and Egger and Kreickemeier (2009), for instance, looked at the effect of trade liberalization on wage inequality, given that globalization irrevocably leads to the opening up of economies and hence more international trade. Other studies such as Manasse and Turrini (2001) and Yeaple (2005) focus on how the size of trade barriers such as transportation cost, which captures the ease of trade and hence globalization, affects wage inequality. Feenstra and Hanson (1996) on the other hand measured globalization by the extent of outsourcing, which is defined as the import of intermediate inputs by domestic firms.

Nevertheless, the logic behind how globalization, regardless of the different measures used to capture it, leads to wage inequality is generally agreed on to be linked to firms' productivity. Bernard and Jenson (1999) found that exporters are more productive and pay higher wages. In other words, firms are selected into exporting based on their productivity and this concept is supported by the Melitz model (Melitz, 2003), which found that a transition from autarky to an open economy leads to increased average productivity among the surviving firms and that only the most productive firms are selected into exporting. Yeaple (2005) argues that the lowering of trade barriers provides incentives for exporting firms to adopt better technology that favours the skilled workers to increase their productivity, therefore leading to wage inequality as the least skilled workers are made redundant. In other words, increased competition for skill when trade barriers fall increases the skill premium and hence widen the wage gap between the skilled and unskilled workers according to Manasse and Turrini (2001).

A similar view is that skill-biased technological change (SBTC) due to globalization has accounted for the main bulk of income inequality (Gregg and Manning, 1997). SBTC refers to the phenomenon whereby technological advances results in better production methods that generally favour the skilled workers and make unskilled workers more redundant, therefore culminating in wage

inequality. Other studies (Weng, 2013) point to the role of unskilled foreign workers influx due to globalization in widening wage gap between the skilled and unskilled workers. Unskilled foreign workers are usually paid lower wages and hence their extensive employment suppresses domestic unskilled wages.

There are also studies that focus on how globalization affects the non-wage components of income such as executive compensation and profits. Sanders and Carpenter (1998), Oxelheim and Randøy (2005), Gerakos, Piotroski, and Srinivasan (2009) for instance found that CEO compensation increases when firms undergo internationalization, which is akin to globalization. In addition, Lin (2013) found that income inequality, which can be captured by CEO-to-worker pay ratio, is 47% higher among internationalized exporting firms and multinational firms (MNCs) than non-exporting domestic firms. This is mainly a result of CEO compensation being positively tied to firm's profit whereas worker's wages being solely determined in the labour market. Therefore, globalization generally only benefits the CEO's income at the top end of the income spectrum due to increased firm productivity, size and profits when the firm opens up to export and multinational activity.

Many studies have also looked at the role of education in influencing income inequality. Using Barro and Lee education level attainment data set, existing studies have had differing results on the effect of average education attainment level on income inequality. Becker and Chiswick (1966) for instance found a negative relationship between average level of schooling and income inequality across regions in the United States whereas Ram (1984, 1989) found that mean schooling has no significant effect on income inequality. Gregorio and Lee (2002) argue that if the returns to education increase with education level, increase in average education attainment level may serve to aggravate income inequality. This is because for the same increase in schooling years in the tertiary and secondary level for instance, a university graduate will experience a greater pay rise than a high school graduate as the returns to tertiary education surpass that of secondary education. Therefore, the

key is to look at the distribution of education or in other words education inequality. Nevertheless, studies by Castelló and Doménech (2014) have shown that improvement in education inequality plays only a small role in improving income inequality. Improvement in education inequality is often offset by globalization effects that serve to aggravate income inequality. Examples of such globalization effects include skill-biased technological change (Katz and Murphy, 1992) and financial openness. Most importantly, Castelló and Doménech (2014) argue that recent decrease in education inequality mainly due to a huge decline in illiteracy worldwide, does not improve income inequality simply because of the low returns of primary education that does not increase wages at the bottom end by much.

As for the relationship between hosing prices and income inequality the existing literature has focused only on the impact of income inequality on housing prices and not on the reverse case that we want to examine. Most studies model the effect of income inequality on housing prices through a supply and demand analysis. Studies that adopt this framework have had varying results in their regressions of housing price on variables that capture income inequality, such as Gini coefficient. Matlack and Vigdor (2006) for instance did such studies using United States metropolitan areas data and find that the elasticity of housing supply is a major factor that determines the sign of the relationship between housing prices and income inequality. In areas with tight housing market, increasing income inequality has a more positive effect on housing price proxies. However, a negative effect of income inequality on housing prices is discovered in other areas with slack housing markets. This ambiguous regression result in the United States is supported by Maattanen and Tervio (2010). Yet, in another study done by Dewilde and Lancee (2012) on the housing markets in twenty-eight European countries, they find that increases in income inequality captured by a positive change in Gini coefficient, has an undeniable positive effect on housing prices in the European countries.

The relationship between income inequality and housing prices is likely to vary from country to country. Whether it is a one-way causal relationship or a feedback relationship needs to be studied within the specific conditions of a country. In this context, cross country studies are not the best to establish this causal relationship and we have to focus on the evolution of the relationship between these two variables over time.

3. Some theoretical considerations

Extending the theoretical framework of Helpman, Meltiz and Yeaple (2004), Lin (2014) derived the following relationship to explain the CEO-to-worker pay ratio of a firm:

$$\frac{\pi(x)}{w} = \frac{H}{w\varepsilon}\left(\frac{P}{w}\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon-1} A(x)^{\varepsilon-1} - f \,. \qquad (1)$$

In this model, CEO compensation is assumed to be a positive function of firm's profit π, *x* is human capital, *w* is the average worker wage rate determined in a competitive labour market, *H* is aggregate expenditure, *P* is product price, *A* is firm's productivity, *f* is a measure of fixed cost and ε is elasticity of substitution in a constant elasticity of substitution (CES) utility function. In analysing the impact of globalization, what Lin (2014) has shown is that $\pi(x)/\mathrm{w}$ of a multinational firm is higher than that of an exporting firm, which in turn is higher than that of an autarkic firm.

In relation to a housing construction firm, (1) shows that the CEO-to-worker pay ratio of the firm increases as housing prices rise relative to wages. To measure this impact empirically we need data on total earnings, not just labour incomes. As we have argued earlier re-distributional effects of rising housing prices are reflected mostly in non-labour earnings. Since we have to work with labour incomes a question arises as to whether housing prices link at all to a labour income ratio like P90/P10. We can show a link by looking at sectors that are closely related to the housing market, in particular the construction and financial sectors.

Consider the labour supply in the construction sector, the supply of average construction workers and the supply of professional and managerial staff. The construction sector in Singapore depends heavily on foreign labour and also records the lowest wages among the major sectors (excluding the commerce sector). It would be reasonable to assume that the labour supply of average construction workers is infinitely elastic and a burgeoning housing market does not alter the average wages of these construction workers by much. Therefore, when private residential property prices rise rapidly

the profitability and mark-ups developers receive should also increase if land prices and material costs do not rise in tandem. Professional and managerial staff, on the other hand, is in short supply and in high demand. When profitability of construction firms improves the salaries and bonuses of professional and managerial staff are likely to increase by a larger proportion than those below them. As a result the labour income gap between average workers and professional and managerial group is likely to widen.

The finance and business services sector records the highest average wages in Singapore. This sector needs more skilled workers and depends less on low-skilled foreign workers. When home prices rise rapidly home buyers incur large mortgage loans. Moreover, a burgeoning housing market also increases other financial transactions in the sector and improves profitability. This is likely to raise the labour earnings (including bonuses) of the high end earners of the finance and affiliated services while low-end wages remain less affected. Similar arguments hold for other sectors related to the housing market. For example, higher transaction prices imply higher commission for real estate agents and lawyers who underwrite the contract.

4. Data

Given the possible endogeneities of the regressors we need to formulate a cointegrating regression to obtain consistent estimates. This also requires long time series. We, therefore, use quarterly data over the period 1981Q1-2013Q3. Not all data series that we need are available at quarterly frequency. Therefore, we had to use some interpolation methods to covert annual series to quarterly frequency.

Sufficiently long time series of income distribution data are not available. The Singapore Department of Statistics (DOS) provided us resident household income from work by age groups and income deciles. We took the household share weighted average of incomes of different age groups to represent the overall income of each decile. Since income data represent the upper limit of the average monthly household income for each decile, we denote them by percentile values P10, P20,..,P90. The income data for the top income decile (91^{st}-100^{th}) are not available. Therefore, we use the income percentile ratio P90/P10 and P90/P20 to measure income inequality. These data that include employer's Central Provident Fund (CPF) contributions are available annually only from 2000. Prior to this, household income without employer's CPF contribution is available for 1990, 1995 and annually since 1997. The average income ratio with and without employer's CPF

contribution is about 1.1. We multiplied the income data before 2000 by 1.1 to align them with income since 2000.

We converted the annual income data to quarterly frequency using a mixture of a mixed-frequency regression technique developed by Abyesinghe (1998) and the Chow-Lin related series method (see Abeysinghe and Gulasekaran, 2004). The related series we used is the average wage rate (average monthly earnings). This series is available quarterly since 1980. After an initial experimentation with annual income and wage data we assume the following dynamic regression relationship at quarterly frequency:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 w_t + \beta_3 w_{t-1} + u_t \qquad (2)$$

where y_t and w_t are the logarithm of household income and average wage respectively. Since y_t is observed only annually, to estimate the parameters of (2) Abeysinghe (1998) introduced a transformation to convert (2) to annual frequency without losing quarterly data on w_t. This leads to a non-linear model and we used a non-linear least squares method to obtain the parameter estimates of (1). For illustration, the estimated regression over 1997-2013 for P10 is:[3]

$$\hat{y}_t = \underset{(0.258)}{-0.504} + \underset{(0.051)}{0.924}\, y_{t-1} + \underset{(0.745)}{1.784}\, w_t - \underset{(0.733)}{1.657}\, w_{t-1},\ R^2 = 0.87. \qquad (3)$$

where the numbers in parentheses are standard errors. We calibrated a starting value (y_1) for 1980Q4 and obtained the predicted values $\hat{y}_t$ at quarterly frequency since 1981Q1 using quarterly w_t series. We then used intercept adjustments to align $\hat{y}_t$ with observed y_t. The same method was used for P20 and P90.

For housing price we use the private median price series released by the Urban Redevelopment Authority. This series is available quarterly since 1975. Housing prices for other quantiles are not available.[4] We deflate the housing price by the consumer price index (CPI) to capture the impact on income inequality of a rise in housing prices over and above the general inflation rate. Deflating by CPI tends to over-deflate the housing price at times when housing prices and rents rise rapidly.

[3] Since labor force surveys are conducted in the mid-year and data are reported against June we assign the annual income figures to the second quarter of each year.

[4] More discussions on Singapore's housing market and different housing price series are found in Abeysinghe and Gu (2011, 2013).

Rising rents are captured in the CPI. However, our results remain very similar whether we use the un-deflated or deflated housing prices.

As we have seen in Section 2, globalization increases the demand for skilled workers. However, educational improvements also exert their own independent dynamic effects on income inequality. Given the mixed results that we have seen in other studies on the relationship between education and income inequality, it is important to measure education properly. Therefore, to capture the impact of rising higher education levels on income inequality we use the proportion (percentage) of university degree holders in the workforce.

Annual data on total employment and quarterly data on change in employment are available (DOS database). By combining these two series we can easily work out the total employment series at quarterly frequency. Annual data on the total number of university degree holders in the workforce are available for the resident population from 1991. The population census provides these data for the census years 1980 and 1990. To fill the annual numbers between these two years we used the annual resident population as a predictor. The number of resident degree holders is a smoothly increasing variable. Therefore, we used SAS spline interpolation method to convert this series to quarterly frequency. Ideally we should be using either the proportion of resident degree holders in the resident employed workforce or total degree holders in the total employed workforce. (Note that Singapore workforce includes substantial number of non-permanent residents.) Unfortunately the necessary data are not available to compile a long quarterly series of resident employed workforce.

Choosing appropriate variables to capture the effect of globalization on income inequality is a difficult task. Most commonly used measures of trade openness are not that suitable for Singapore because of Singapore's extreme openness. For example, export or trade share of GDP in Singapore is more than 100% and it is less indicative of the globalization impact that we are considering. Given our measures of labour income inequality, a much better indicator of globalization effect is the productivity ratio between the traded sector and the construction sector. Abeysinghe and Choy (2004) used the manufacturing sector to represent the traded sector because 60-70% of manufacturing output is exported. We find that the productivity ratio between the manufacturing and construction sectors does not provide a cointegrating regression that we are looking for. It should also be noted that the manufacturing sector employs a large proportion of low-cost foreign workers. Ideally the productivity ratio variable should also be able to capture the effect of foreign workers on income inequality. The other sector that is closely related to the traded sector is finance

and business services sector. For this reason and for the reasons pointed out in Section 3 we use the productivity ratio between the finance business services sector and the construction sector.

5. Empirical results

The variables we use in our analysis are the household labour income ratios denoted by P90/P10 and P90/P20, private median housing price denoted by Ph and the deflated price denoted by Ph/CPI, the percentage share of resident degree holders in total employed workforce denoted by GradShare, and the ratio of labour productivity of the finance and business services sector to construction sector denoted by ProdRatio. Figure 1(a) plots the income ratios. Interestingly both ratios show a drop in the income gap in the early 1980s. In fact, P90/P20 continued to drop for a longer time period and then both variables started to increase rapidly since 1990 till about 2005. Subsequently P90/P10 has continued to increase at a slowing rate whereas P90/P20 has flattened out and started dropping since 2011. In 2013, the household labour income of the 90^{th} percentile was about 12.5 times that of the 10^{th} percentile and about 7 times that of the 20^{th} percentile.

Figure 1(b) plots the private median housing price. A median priced unit (basically a condominium unit) that was sold for about $300,000 in the early 1980s costs more than $1.3 million in 2013. Among the four housing price escalations mentioned in Introduction the most prominent one took place in the period 1987-96. This also coincided with Singapore's rapid and uninterrupted growth during which income inequality also increased. Although housing prices increased to a new peak by 2013, when deflated by the CPI, the 1996 peak remains prominent. Even in terms of housing affordability measured by the ratio of housing price to lifetime income, the 1996 peak remains unbeatable (Abeysinghe and Gu, 2013).

Figure 1(c) plots the GradShare series. The economically active resident degree holding population shows an exponential increase (not shown graphically for brevity). This is also reflected in the GradShare series. It records a drop in 2007 because of the drop in total employment level as a result of the Global Financial Crisis. In 2013, the economically active graduate population was about 20% in total employment and about 32% in the resident workforce. Figure 1(d) plots the ProdRatio. Construction sector productivity shows a mild improvement over the 1987-97 period and then drops and stays flat over the rest of the period. Therefore, the major cycles in the ProdRatio are a result of the fluctuations in finance and business services productivity.

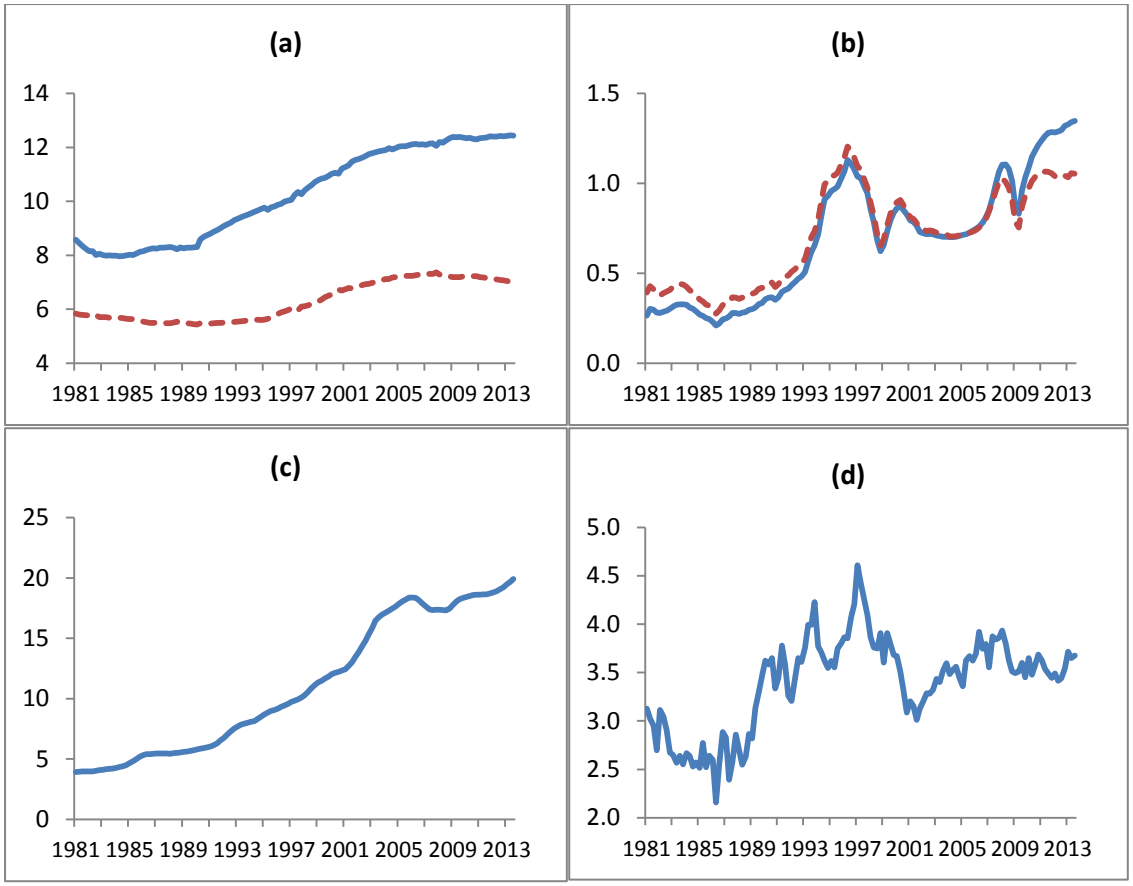

Figure 1. (a). Household labour income ratios, P90/P10 (solid line), P90/P20 (dashed line)
(b) Private median house price (S$ million, Ph solid line, Ph/CPI dashed line, CPI base=2005)
(c) Resident university degree holders share (GradShare %) in total employment
(d) Productivity ratio (ProdRatio), finance & business services/construction

In the regression analysis we use log-transformed Ph and Ph/CPI series and keep the other variables untransformed.[5] Unit root tests based on both ADF and KPSS tests indicate that all these variables can be characterized as I(1) processes. P90/P20 does not form a cointegrating relationship with the other explanatory variables and we report in Table 2 some estimates of this regression only for illustrative purposes. The housing price effect on P90/P10 remains not much affected by the use of ln(Ph) or ln(Ph/CPI) in the regression; therefore, we present only the results based on ln(Ph/CPI).

First we carried out a cointegration analysis using Johansen methodology for different combinations of the variables and find that P90/P10, ln(Ph/CPI), GradShare, and ProdRatio form a cointegrating relationship with one cointegrating vector. These results are presented in Table 1. The adjustment coefficients of the ln(Ph/CPI) and Gradshare equations are not statistically significant indicating that

[5] Formulation in (1) implies a log-linear form. However, a log-linear form does not work well with the data we have.

these two variables are weakly exogenous for the parameters of the P90/P10 regression. However, we cannot say the same thing about ProdRatio. We also carried out Granger causality tests on the lagged coefficients of the VECM model (Table 1). These tests show that there is no Granger causality at all among these variables. Weak exogeneity and no Granger causality makes ln(Ph/CPI) and GradShare strongly exogenous for the parameters of the P90/P10 regression. Essentially these results show that causality is from housing price to income inequality and not the other way round, at least in the Singapore context.

Table 1. VECM test results based on VAR(4) specification

	P90/P10	ln(Ph/CPI)	GradShare	ProdRatio
Cointegrating vector	1	-1.446***	-0.276***	1.067***
	-	(0.335)	(0.016)	(0.260)
Adjustment coefficients	0.036**	0.018	-0.002	-0.169***
	(0.016)	(0.011)	(0.018)	(0.051)
Granger causality tests on lagged coefficients				
Δ(P90/P10)	-	3.303	2.772	0.941
		(0.508)	(0.597)	(0.919)
Δ(ln(Ph/CPI))	7.202	-	2.485	7.591
	(0.126)		(0.647)	(0.108)
Δ(GradShare)	3.252	2.529	-	5.425
	(0.517)	(0.640)		(0.246)
Δ(ProdRatio)	4.704	7.689	5.725	-
	(0.319)	(0.104)	(0.221)	

Notes: Numbers in parentheses in the upper panel are standard errors and those in the lower panel are p-values for the Wald test under the null that the relevant lagged coefficients are jointly zero. The asterisks ***, **, and * indicate the statistical significance at the 1%, 5%, and 10% levels respectively.

As for the long run cointegrating regression coefficients the Johansen estimates are not that ideal because these estimates are sensitive to the VAR order selected. Since the OLS estimates of a cointegrating regression are not affected by the problem of over-parameterization and also for the need to introduce non-linear effects into the model, we report the OLS results in Table 2. As a cross check we also obtained estimates from dynamic OLS (DOLS) regressions by setting the lead-lag length to 3.[6]

[6] Note that the t-statistics of the cointegrating coefficient estimates from DOLS follow a standard normal distribution (Stock and Watson, 1993) whereas OLS t-statistics do so only if the explanatory variables are exogenous.

Table 2: OLS and dynamic OLS estimates

	Dept var: P90/P10					P90/P20
	OLS (1)	OLS (2)	OLS (3)	DOLS (4)	DOLS (5)	OLS (6)
House price ln(Ph/CPI)	-	0.253***	0.342***	0.255**	0.188*	- 0.038
		(0.071)	(0.082)	(0.125)	(0.099)	(0.090)
GradShare	0.560***	0.496***	0.494**	0.510***	0.571***	0.149***
	(0.020)	(0.026)	(0.026)	(0.043)	(0.040)	(0.028)
GradShare squared	-0.011***	-0.009***	-0.009***	-0.010***	-0.011***	-0.0004
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
ProdRatio	-	-	1.214***	1.565*	0.243	- 0.353
			(0.395)	(0.809)	(0.789)	(0.433)
ProdRatio squared	-	-	-0.193***	-0.240*	-0.062	0.019
			(0.058)	(0.122)	(0.115)	(0.064)
Constant	5.766***	2.761***	-0.233	0.133	2.950	6.188***
	(0.095)	(0.850)	(1.160)	(2.065)	(1.773)	(1.272)
Sample period	1981-13				1987-13	1981-13
Residual $\hat{\rho}_1$	0.88	0.87	0.84			0.91
Residual ADF	-4.76**	-4.65**	-4.59*			-2.09
ADF 10% critical value	-3.50	-3.87	-4.52			-4.52
R square	0.99	0.99	0.99			0.93
AIC	-0.50	-0.58	-0.65			-0.47
BIC	-0.43	-0.49	-0.52			-0.33

Notes: Numbers in parentheses are standard errors. The asterisks ***, **, and * indicate the statistical significance at the 1%, 5%, and 10% levels respectively.

The regression estimates reported in Table 1 indicate that rising GradShare leads to higher income inequality while rising ProdRatio (proxy for globalization) reduces income inequality. These results are somewhat counter-intuitive. There is the possibility that the effect of these variables on income inequality is non-linear. To capture this we introduced their squared terms into the regression. The results now look different and very interesting. Table 2 reports the results of various regression specifications. The table also shows the residual autocorrelation at lag 1 ($\hat{\rho}_1$) and the residual based ADF test for cointegration. Although the ADF test supports cointegration of regressions (1) – (3), the AIC and BIC values favour the full model (3).

We find that GradShare and its square are the most robust explanatory variables of labour income inequality measured by P90/P10. The coefficient estimates do not change much even when we use a shorter sample period 1987-2013 (Column 5). These estimates show an inverted U-shape effect of rising GradShare on labour income inequality. Various estimates we obtained indicate that when the

GradShare increases above roughly 25%, income inequality resulting from rising GradShare should start to decline. As of 2013, the GradShare was 20%. In retrospection it is not difficult to understand why the GradShare is a key determinant of the household labour income ratio P90/P10. This is primarily a result of "assortative mating"; well educated tend to marry well educated while less educated tend to marry less educated. A household made up of a working graduate couple earns a lot more than a household made up of a less educated couple. The lowest income decile is made up of less educated and low skilled workers.

The ProdRatio also shows an inverted U-shape effect on P90/P10. However, it is not as robust as the GradShare in explaining income inequality (columns 4 and 5). Various estimates indicate that when the ProdShare exceeds about 3, labour income inequality should start to decline. In fact, ProdShare surpassed this peak value in the early 1980s. So further increases must have contributed to reducing income inequality. This goes against the argument that globalization worsens income inequality. Instead of ProdShare we also tried the share of non-oil domestic exports (NODX) in total expenditure (C+I+G+X). This variable also shows a negative effect on income inequality. If these variables capture globalization effect at all, it seems that globalization has helped in reducing labour income inequality in Singapore. This needs further analysis.

Moving to the key variable of our analysis, regressions (2)-(4) show a statistically significant effect of rising housing prices on P90/P10. However, this effect drops substantially when the sample period is shortened to 1987-2013. Moreover, the measured effect is small. Regressions (3) and (4) indicate that a 1% increase in Ph/CPI increases P90/P10 by about 0.003. However, the cumulative effect may not be negligible if housing prices escalate as it happened during different episodes listed earlier. These results also indicate that overall earnings (labour and non-labour earnings) data would capture the re-distributional effects of housing price escalations better.

6. Conclusion

The link between income inequality and housing prices is not a well-researched area. A limited number of studies have focused on the impact of rising income inequality on housing prices. The reverse impact does not seem to be an area that caught the attention of researchers. When housing wealth cannot be monetized easily, rapid increases in house prices may widen the income gap in a country through income redistribution away from home buyers for owner occupation to property developers, rental property owners and financiers. Although this redistribution effect is largely reflected in non-labour earnings, we tested the hypothesis using household labour income data from

Singapore within a cointegrating framework. The results show a small but statistically significant positive effect of rising private residential property prices on the labour income percentile ratio P90/P10. We can, therefore, expect a much bigger effect on the overall earnings ratio that includes non-labour earnings.

As a by-product of this exercise, we find that increasing university education, measured by the proportion of resident university graduates in the total workforce (GradShare), has been a major contributor to the widening labour income gap in Singapore. The GradShare has a non-linear effect on labour income inequality. Our results show that it will contribute to widen the income gap till it reaches about 25% (2013 share was 20%) and then further increases will help in reducing the income gap. Assortative pairing in marriages and eventual decline in returns to higher education may explain this non-linear relationship. We also examined the effect of globalization on income inequality. Quite contrary to standard arguments, our measures of globalization indicate that globalization has helped in reducing the labour income gap in Singapore. This obviously needs further analysis.

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