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The motorcycle to car ownership ratio: inflation and it's indirect effects

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Abstract. In the initial phase of economic development, motorcycle ownership rise with the growing demand in transportation. However, as income rose and perhaps due to convenience, safety and prestige, motorists opt to purchase car than motorcycle. Under high inflation, motorists tend to choose cheaper mode of transportation, like motorcycles and mopeds, which in turn leads to higher ownership ratio of motorcycle to passenger car (MTPC). On the other hand, economic studies indicate that the correlation between inflation and economic development is nonlinear; it is negative for high levels of inflation, but positive for low levels of inflation. Consequently, this may lead to a rise in MTPC ownership ratio at some levels of income and a decline at others. This study focused on understanding how inflation affects the MTPC ownership ratio indirectly and the factors underlie this relationship. The data used in this analysis contained a sample of 76 countries at various levels of economic development growth over the 51-year period between 1963 and 2013 using panel data analysis. The indirect effect of the inflation on the MTPC ownership ratio varied in accordance with increases in the inflation. Policy implications of the study were discussed in the conclusion part of the study.

1. Introduction

The existing empirical evidence indicated that there is a Kuznets curve between motorcycle ownership and income growth. Motorcycle ownership rose with per capita income at a lower level of GDP, but decreased with per capita income at a higher level of GDP [1-4]. The literature explained motorcycle ownership increased with the transportation demand in the beginning of the economic development. However, as income rose motorists opt to purchase car than motorcycle. This may due to convenience, safety and prestige. The inverted U-shaped relationship is not mainly explained by per capita income, but also by the inflation rate [4]. Under high inflation, motorists tend to choose cheaper mode of transportation (i.e. motorcycles and mopeds), which leads to higher ownership ratio of motorcycle to passenger car (MTPC) [4]. Economic studies indicate that the correlation between inflation and economic development is nonlinear; it is positive for low levels of inflation but negative for high



levels of inflation [5-8]. Consequently, this may lead to a rise in MTPC ownership ratio at some levels of income and a decline at others.

This paper discussed the indirect impact of inflation on the MTPC ownership ratio, transmitted via the impact of inflation on per capita income.

2. Review on economic growth and inflation

Previous studies showed that inflation has detrimental impact on economic development in medium and long term [9-11]. Nevertheless, several literatures suggested that the relationship between economic growth and inflation in long term is nonlinear. The correlation between these two variables is positive or nonexistent below certain threshold levels, but hampers the economy when inflation is above that threshold level [5-7, 12].

The first author who classifies this non-linear link was Fischer (1993). He concluded that inflation boost economic growth when it is below a threshold value, but has a negative impact if it is above. Various literatures summarized that the inflation-growth impacts are less apparent at low rates of the inflation but significant negative at high inflation rate [12-13]. The results are depending on the inflation threshold level and it changes according to the group of countries being assessed (exp. developing, developed, or a mixture of both). The inflation threshold is lower in developed than in developing countries [13].

Economic literature found that inflation hinders economic growth once surpasses inflation threshold; however it promote growth before the threshold level. As previous studies found that MTPC ratio has inverted-U shape relationship with economic growth. Therefore, an indirect impact from inflation affecting economic growth is existing hence shaping MTPC ratio. This assumption is presented in the following section.

3. Methodology

The indirect effect of inflation on MTPC ownership ratio can be reflected on the effect of inflation on per capita income and the subsequent effect of per capita income on MTPC ownership ratio. The indirect effect can be expressed as,

$$\frac{dMTPC}{dCPI} = \frac{\delta MTPC}{\delta GDP} \frac{\delta GDP}{\delta CPI} \quad (1)$$

where MTPC is the MTPC ownership ratio, CPI represents consumer price index, and GDP is a measure of real GDP per capita.

This study utilized the panel data regression methods to estimate the equation 1 equation model. Due to the high accessibility and availability of cross-country time series data sets, panel regression modeling has becoming more favorable method. Panel data are more competent due to its better estimations and more informative. Linearity between variables is being reduced [15]. First, linear panel model is used to estimate the impact of CPI on per capita income (refer to equation 2). Then, the effect of per capita income and CPI on MTPC ownership ratio is estimated using panel model with the AR(1) disturbance term (refer to equation 3). In the panel regression analysis, the Hausman test is used to assess the suitability of a fixed or random effects model under the null hypothesis that there is no correlation between country-specific intercept and the independent variables in the model. When the null hypothesis is rejected, fixed effect estimator is chosen. The two equations are expressed as,

$$\ln GDP_{it} = \varphi_i + \alpha_1 CPI_{it} + \alpha_2 Y_{it} + \varepsilon_{it} \quad (2)$$

$$\ln MTPC_{it} = \omega_i + \beta_1 CPI_{it} + \beta_2 \ln GDP_{it} + \beta_3 (\ln GDP_{it})^2 + \beta_4 X_{it} + \beta_5 T + \zeta_{it} \quad (3)$$

where T denotes a time trend, ω_i and φ_i represent country fixed effects; ζ_{it} and ε_{it} refer to the error term; The sub-index i refer to a country and the sub-index t refers to time; Equation 2 consists of a few control variables, Y, specifically total of imports and exports of goods and services, physical capital

stock per worker, and human capital index. X , in Equation 3 specifies other control variables, which include road density and urban to rural population ratio.

4. Data

This study included 1900 annual observation of an unbalanced panel dataset. It is consisting of 77 countries from the year 1963-2013 (51 years); some variables were missing in the sample for some countries and years. The countries list included in this study is presented in Table 1.

The depended variable for equation 2 was the per capita Real Gross Domestic Product (GDP) (US\$ 2011 constant prices: Chain series) was used as a proxy for per capita income. There will be a positive relationship between openness of trade and economic growth [17]. According to the Solow growth model, the capital stock has positive impact on economy growth [17-18]. There were two different types of capital stock, human and physical capitals respectively were included in equation 2. Human capital refers to the productive skills, education level, and work-related capabilities in the employment force while the physical capital stock refers to the essential infrastructure (i.e. water supply, buildings, roads, tools and technology). Physical capital stock per worker (CPW) was calculated by dividing physical capital stock by the number of workers. It was calculated as 'rkna' divided by 'emp', where 'rkna' was the capita stock at constant 2011 national prices and 'emp' was the number of persons engaged in millions [18]. The consumer price index (CPI), a measurement for inflation was used as a proxy for power to purchase vehicles [19].

MTPC ownerships ratio, the dependant variable in equation 3, was obtained by dividing the total of motorcycles and mopeds by the total of passenger cars (for a specific country and the year). The other two control variables for equation 3 the total road length per thousand populations and were the urban to rural population ratio. The urban to rural population ratio was used to investigate the impact of population concentration on MTPC ownership ratio. The total road length per thousand population was to explain the travel patterns and vehicle ownership [20]. Table 2 shows the data sources and definitions used in this analysis.

Table 1. The list of the countries and the available years of data.

No.	Country	Observation	Period From-To
1	Australia	30	1963-2004
2	Austria	45	1963-2010
3	Bahrain	26	1987-2013
4	Bangladesh	9	1990-2003
5	Belgium	48	1964-2011
6	Benin	5	1992-1996
7	Botswana	14	1981-2005
8	Brazil	3	2000-2004
9	Brunei	17	1991-2011
10	Bulgaria	20	1986-2011
11	Cameroon	13	1968-2008
12	Canada	30	1969-2009
13	China	19	1990-2013
14	Colombia	20	1983-2013
15	Costa Rica	25	1984-2013
16	Cote d'Ivoire	10	1966-2007
17	Cyprus	32	1975-2013
18	Czech Republic	21	1993-2013
19	Denmark	34	1977-2013
20	Ecuador	20	1984-2013
21	Egypt	19	1982-2010
22	Estonia	18	1996-2013
23	Finland	50	1963-2013
24	France	40	1963-2010
25	Germany	18	1991-2013
26	Greece	40	1971-2013
27	Hong Kong	20	1981-2013
28	Hungary	22	1991-2013
29	Iceland	51	1963-2013
30	India	41	1965-2012
31	Indonesia	34	1966-2013
32	Ireland	42	1965-2013
33	Israel	27	1987-2013
34	Italy	38	1963-2005
35	Japan	49	1963-2011
36	Jordan	11	2003-2013
37	Kenya	33	1966-2013
38	Korea, Rep.	38	1971-2013
39	Laos	12	1990-2002
40	Latvia	17	1995-2013
41	Lithuania	19	1995-2013
42	Luxembourg	27	1975-2009
43	Malawi	3	1980-1982
44	Malaysia	48	1963-2012
45	Malta	10	1998-2009
46	Mauritius	31	1980-2013
47	Mexico	15	1990-2013
48	Mongolia	10	1994-2003
49	Morocco	34	1969-2011
50	Nepal	3	2010-2012
51	Netherlands	43	1963-2012
52	New Zealand	38	1971-2013
53	Nigeria	11	1973-1996
54	Norway	49	1963-2013
55	Pakistan	38	1967-2012
56	Panama	16	1977-2009
57	Peru	11	2000-2013
58	Philippines	26	1981-2011
59	Poland	24	1990-2013
60	Portugal	17	1963-2003
61	Romania	19	1990-2012
62	Slovakia	18	1995-2013
63	Slovenia	22	1992-2013
64	South Africa	23	1967-2001
65	Spain	45	1967-2013
66	Sri Lanka	21	1969-2010
67	Swaziland	14	1987-2003
68	Sweden	37	1973-2013
69	Switzerland	41	1963-2013
70	Syria	18	1963-2010
71	Thailand	33	1967-2011
72	Togo	14	1980-2007
73	Tunisia	16	1983-2013
74	United Kingdom	39	1975-2013
75	United States	43	1970-2013
76	Vietnam	12	2000-2011

Table 2. Data sources for variables in equation 2 and 3.

Data source		Definition	Variable
International Federation	Road	Motorcycle to passenger car ownership ratio	MTPC
		Per capita Real GDP (In mil. 2011US\$)	GDP
Penn World Table version 9.0		Physical capital stock per worker	CPW
		Human capital index	HC
		Consumer price index (2010 = 100)	CPI
World Indicator	Development	Ratio of urban population to rural population	URBRUR
		Road density (km per 1000 population)	ROAD
		Sum of import and export goods and services (% of GDP)	TRADE

5. Results and Discussions

5.1. Model of inflation and per capita income

Table 3 explained the statistic for variables in equation 2 while Table 4 showed three models were used to describe the effect of inflation on per capita income. In order to assess the quadratic relationship between inflation and the per capita income, a quadratic term was added to the natural logarithm of CPI. Model A (in Table 4) model the linear and quadratic terms of inflation to investigate the link between per capita income and inflation. Trade, CPW and HC were included to assess the robustness of the estimation of inflation (Models B and C in Table 4).

Table 3. Description statistics for all variables used in equation 2

Variable	Obs	Average	Std. Dev.	Minimum	Maximum
GDP	1900	18671.11	13961.01	412.797	84288.27
CPI	1900	56.47824	33.07998	1.004284	131.8465
HC	1900	2.586621	0.65639	1.039415	3.726472
TRADE	1900	78.01422	49.33161	7.529721	455.4151
CPW	1900	174479.5	122320.9	5.548396	564.9913

The estimated results in Models A and B (in Table 4) revealed that the coefficient for inflation was significantly positive whereas the coefficient on its squared term was estimated to be negative. This shows that the per capita income increased with inflation at a lower level and decreased with inflation at a higher level. The turning point happened at CPI value of 76.2 (at 65 percentile of CPI). 'Trade', 'CPW' and 'HC' are estimated to be significantly positive, in line with expectations. We used Model A to estimate the pure effect of inflation on MTPC ownership ratio.

The Hausman test showed that a fixed-effect estimator was more suitable in Models A and B, whereas a random-effect estimator was more appropriate in Model C. The inverted-U relationship disappeared once the data were controlled for the human capital index. Interestingly, the CPI coefficient in Model C was negative, and the CPI squared was positive (U-shaped). However, the slope of the per population income and CPI relationship changed from negative to positive at lower CPI levels (turning point 20.5). This showed that the CPI had a positive impact on per population income throughout most of the sample range.

Table 4. The effect of inflation on per population income.

Variables	Model A	Model B	Model C
ln(CPI)	3.537 *	3.518 *	-0.145*
(ln(CPI)) ²	-0.408 *	-0.468 *	0.0240*
TRADE		0.005*	0.0008*
CPW		0.006*	0.001*
HC		0.	1.099***
Constant	2.320 *	1.725*	6.375*
No. of observation	1824	1824	1900
No. of groups	76	76	76
R squared (within samples)	0.8134	0.8572	0.8272
Hausman test (chi-square)	8721.54*	13251.51*	N.A.
Random- or Fixed-Effect	FE	FE	RE
Turning point	76.2	43.0	20.5

Remarks:

*Significant at 1%

RE-Random-effect, FE- Fixed-effect.

5.2. Model of consumer price index and the MTPC ownership ratio

Wherever Table 5 explained the statistics for all variables used in equation 3. The estimated results in Table 6 confirmed a significant inverted U-shaped relationship between the MTPC ownership ratio and the per capita income. This result is consistent with previous study which reported that MTPC ownership ratio inclined with per capita income at a lower level and declined with income at a higher level [4]. The threshold level for the MTPC ownership ratio was estimated in the range of US\$2800 to US\$3770.

Table 5. Descriptive statistic for variables included in Equation 3

Variable	Obs.	Average	Std. Dev.	Minimum	Maximum
MTPC	1900	1.042	5.443	0.00115	77.0123
GDP	1900	18623.48	13884.32	412.79	84288.27
CPI	1900	56.366	32.967	1.004	131.847
URBRUR	1900	178.19	3992.71	0.135	100054
ROAD	1900	390520.8	1031661	1150	6550896

The coefficient for the inflation in Table 6 is significantly positive. Inflation raises the price of goods and services, consequently decreasing buying power [20]. As a result, during high inflation stage, travelers choose to obtain lower running cost and price vehicles (i.e. motorcycle and mopeds). Therefore, this will cause a rise in the MTPC ownership ratio.

Model B (in Table 6) showed that the total road length per thousand population is positive on the MTPC ownership ratio. This shows that the MTPC ownership ratio rises with total road length per thousand population. And the road network growth started in urban areas with lower number of lanes and roads. A higher road density is associated with increasing local accessibility and motorcycle ownership. It is anticipated to increase motorcycle more rapidly compare to car ownership at this growth stage

Table 6. Estimates of MTPC

Variables	Model A	Model B
ln(GDP)	2.0137***	1.8997***
(ln(GDP)) ²	-0.1345***	-0.1274***
ln(CPI)	0.1278***	0.1392***
ln(ROAD)		0.0162
ln(URBRUR)		-0.0831***
Constant	-9.1502***	-8.8551***
No. of observation	1900	1900
No. of groups	76	76
R squared (within samples)	0.0822	0.0831
Random or Fixed Effects	RE	RE

Remarks:

*Significant at 1%

RE-Random-effect, FE- Fixed-effect.

In Model C, the coefficient for urbanization was significantly negative. This shows that the MTPC declined with the level of urbanization of a country. As urbanization increases, private cars are expected to be preferable to motorcycles, as they are suited to long-distance trip. The estimated results for Model A were used in estimating the pure impact of CPI on the MTPC ratio.

5.3. Estimation of the indirect effects of consumer price index

The indirect effect is calculated from the product of $\delta\text{MTPC}/\delta\text{GDP}$ and $\delta\text{GDP}/\delta\text{CPI}$ (as indicated in equation 1). The results in Model A (Table 4) show that the turning point for the CPI is at 76.2, while the estimated turning point for the per capita GDP is reached at US\$1,779.

The indirect impact of inflation on MTPC can be divided into four different phases (refer to Figure 1) varies according to the CPI level. A rise in CPI levels is associated with increases in per capita GDP (when the CPI value is below 6.4, phase I), and this would lead to a rise in the MTPC ownership ratio. The indirect impact is estimated to be positive in the first phase, implying that an increase in the CPI increases the MTPC. During this stage (at a low income level and low economic activity), motorcycle ownership was more common than car ownership because of the higher cost of cars, as indicated by [4].

However, when the CPI value is between 6.4 and 76.2, increases in per capita GDP (as a result of increases in CPI) would lead to a decrease in the MTPC ownership ratio (phase II). This is because per capita GDP has already passed the turning point of US\$1,779. The indirect impact changed from positive to negative in the second phase (when CPI growth exceeded 6.4). This shows that due to safety and prestige, more commuters readily switched from motorcycles to private cars at higher per population income levels

As the CPI continued to rise (exceeded the threshold of 76.2, turning point), increases in CPI would hinder the growth of economic and hence increased the MTPC ownership ratio (phase III). The indirect impact changed from negative to positive during this third phase. The reduction in per population income (due to inflation rate rises) arose with a reduction in purchasing power. Therefore, motorists tended to choose vehicles (i.e. mopeds and motorcycles) with lower purchase, maintenance, and running costs in periods of high inflation. This resulted increased in motorcycle ownership at a higher inflation level.

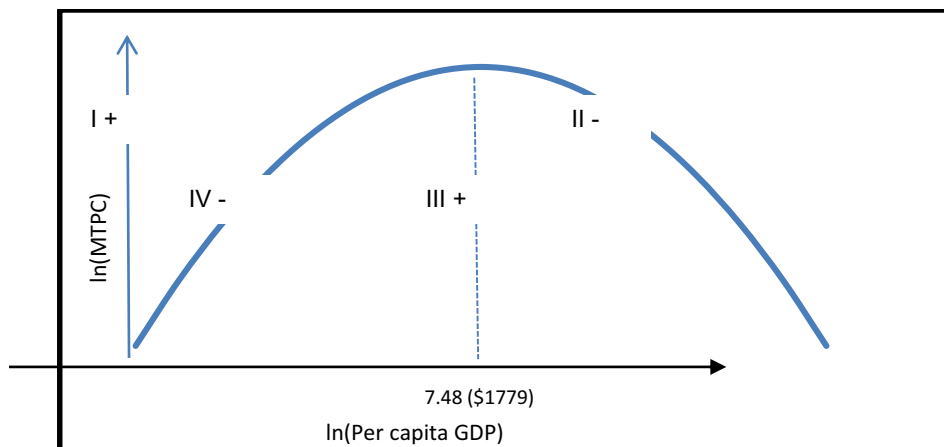
Per capita GDP decreases continuously as the CPI value exceeded 604.19 and this leads to a reduction in the MTPC ownership ratio (phase IV). The indirect impact was estimated to be negative at this phase. Due to resource scarcity, motorcycle ownership will likely to decline and private car ownership can be expected to be low at this stage. The above discussion can be illustrated in Table 7.

Table 7. The impact of CPI on MTPC (Elasticities)

lnCPI	CPI	Estimated ln(per population GDP)	$\frac{\partial MTPC}{\partial GDP}$	$\frac{\partial GDP}{\partial CPI}$	$\frac{\partial MTPC}{\partial GDP} \times \frac{\partial GDP}{\partial CPI}$	Phase
1.6198 (5%)	5.00	6.9794 (\$1,074)	0.1357	2.2151	0.3006	I
3.2593 (25%)	26.05	9.5139 (\$13,547)	-0.5463	0.8768	-0.4790	II
4.0987	60.26	9.9623 (\$21,211)	-0.6669	0.1915	-0.1278	II
4.6052 (90%)	100.48	9.9546 (\$21,049)	-0.6648	-0.2219	0.1476	III
6.9176*	1012.32	7.2587 (\$1,420)	0.0606	-2.1097	-0.1278	IV

Remarks:

* (High CPI, not in data range)

**Figure 1.** The relationship between the MTPC and the per population GDP.

6. Conclusion

This paper assessed the indirect impact of the inflation on the MTPC ownership ratio via the effect of the inflation on per population income and the resultant effect on MTPC ownership ratio. The result indicates that MTPC ownership ratio varies accordance to the rise of CPI at different level. The key finding of this study was that inflation has a non linear effect on MTPC ownership ratio, positive at earlier phase and turn to negative once per capita income is higher. It turned back to positive once reached higher inflation and further negative elasticity which is at resource scarcity phase.

As regards to policy implications, lower level of inflation is associated with a high number of MTPC ownership ratio (phase I). The increased of large motorcycle population and high mobility of motorcyclists indicates that economic growth at lower income levels would lead to a rise in motorcycle deaths [21]. A similar problem also arises at higher inflation rates (phase III). However, the increase of motorcycle ownership at this stage is due to a decline in per capita income. To combat the excessive motorcycle safety problems, some injury prevention and risk control interventions such as segregate motorcycles via the provision of motorcycle lanes, encourage modal shift from

motorcycle to public transportation, raising the rigorous of motorcycle helmet laws and enforcement intensity should be implemented. Nonetheless, for countries that passing through phase II, it is anticipated that passenger car ownership rises rapidly. To adapt the rise of passenger cars they should redirect their country resources to improve and upgrade their road transport infrastructure (i.e. extension of road networks, building more highways and upgrading public transport).

Several limitations of this study should be noted. First, the quadratic function used to describe the link between the MTPC and per capita income as well as between the CPI and per capita income. Once obtained the threshold point, the decline rate is similar with the previous incline rate. This seems unlikely to happen because the downward and upward of (CPI-income and MTPC ratio-income) shape are impacted by several aspects. Thus, for future study other curve fitting methods (i.e. spline function) is suggested. Second, this study assumed only two main private transport modes which are motorcycles and passenger cars. In reality, other transport modes (i.e. bicycling, walking and using public transport) could be chosen to fulfill travel needs. Thus, a possible extension of this study is to assess the modal shift from motorcycles to the above mentioned transport modes and to identify the factors that promote this modal shift.

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