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Biased Technical Change and Economic Growth : The Case of Korea, 1970-2013

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Abstract

This paper explores the pattern of technical change in the Korean economy from 1970 to 2013 and investigates its determinants. We use the Classical growth-distribution schedule to show that the labor-saving and capital-using pattern has predominated. For the rationale behind this Marx-biased technical change (“MBTC”), we focus on the relationship between technical change and real wage growth via the evolution of labor and capital productivity, and verify the historical direction of technical change against the rise and fall of the working class. Furthermore, we find that the deviation during the post-crisis period from the long-run trend of MBTC is not attributable to the vitality of new technological innovations, but rather the reflection of class dynamics over extracting productivity under weaker capital deepening. The results suggest that the recent deterioration of labor share and labor unions in Korea is closely associated with low incentive for technological progress, which contributes to prolonged stagnation.

Keywords: growth-distribution schedule, Marx-biased technical change, labor productivity, capital productivity

1. Introduction

Korea had been one of the fastest growing countries in the post-war period. It recorded a real growth rate of 8.5%, 9.3% and 8.4% during the 1970s, 1980s and mid-1990s, respectively, which earned Korea the title of the “East Asian miracle economy”. Although its dazzling state-led development model declined sharply with the 1997-1998 Asian crisis and the subsequent sweeping neoliberal reforms led to the secular bear phase during the 21st century with a 3.6% growth rate, Korea remains a role model for catching up and even of quickly recovering from the crisis. Given that technical progress is an inherent feature of economic growth, unsurprisingly, Korea’s remarkable technical innovation as a driver of its rapid growth has been in the spotlight for decades.

However, while Korea’s technical progress is allegedly attributed to human capital accumulation fostered by education and trade openness (Lucas 1993) or the strong industrial policies that allocate rents to private entities, which have enabled *chaebols* to defy comparative advantage (Lee *et al.* 2005), the dynamics of technical change associated with the contradictions of capital accumulation have attracted little interest. That is, by belittling the bloody Taylorism, harsh labor repression, the *chaebol*’s overgrown social power, and U.S.-Japan auspices, all of which structured the institutional architecture supporting the capitalist operation in Korea (Hart-Landsberg *et al.* 2007), the above conventional interpretations have treated technical progress as practically neutral with respect to income distribution and as exogenous to class conflict.

The mainstream economic growth literature freely relied on the elusive concept of total factor productivity (hereafter “TFP”) for understanding technical change (Easterly & Levine 2001). Even when addressing theoretically relatively uncontentious labor productivity growth, the literature generally and unavoidably invoked TFP change as its contributing factor. However, despite much effort to estimate the size of TFP in growth accounting, its unreliable assumptions of production functions have baffled the proper investigation of technical changes (Felipe & McCombie 2013). In Korea’s case, we still run up against mixed TFP calculations which even contradict one another.¹

¹ Recent empirical results such as OECD (2015) and Chun *et al.* (2015) find that Korea’s TFP growth

Moreover, within the common framework of calculating TFP, which is nothing more than the residual of growth accounting formulas, we are given few explanations as to where technical progress has originated from and why it has favored capitalists rather than the working class or both.

Instead, we considered how technical progress emerges from within the economic system following in the steps of Classical economists such as Ricardo and Marx, who emphasized the struggle between classes as a motive for technical change (Kurz, 2010). In that vein, we explored endogenous patterns of technical change in the Korean economy for the period 1970 to 2013, the most recent time span of data available. We aimed to find whether technical change has a biased direction and investigated the specific bias determinants, both of which have seldom been discussed in textbook economics.

The induced innovation literature includes neoclassical research such as Kennedy (1964) and Drandakis & Phelps (1966), who modelled the theoretical logic according to which capitalist firms adopt technologies using a specific production factor more intensively in response to a decrease in its relative cost.² Meanwhile, without depending on production function or its unrealistic and tautological assumptions, Duménil & Lévy (1995) and Foley & Michl (1999) stressed the inevitability of the biased technical change, which promises to increase the profit rate at the existing wage so that only ‘viable techniques’ are embraced.³ Accordingly, a growing body of analysis, like that of Foley & Marquetti (1999), Marquetti (2003), Ferretti (2008), Felipe *et al.* (2008), and Vaona (2011), have attempted to empirically demonstrate the bias in the real economy. They show, albeit with some variations in the individual countries and time spans, that the predominant form of technical change in recent decades has been labor-saving and capital-using. Additionally, in explaining why the Industrial Revolution was British in origin, Allen (2011) proves that the very high wages in 18th-century Britain not only induced British firms to invent technologies that substituted capital for labor but also generated the firms’ demand for literacy, numeracy, and trade skills that were necessary for the technological revolution to unfold.

rate and its contribution to economic growth have long been fairly high even before the Asian crisis, while the more widespread recognition is that that the quantitative increase of factor inputs, rather than qualitative TFP, drove Korea’s rapid growth (Young 1995; Krugman 1994).

2 More recently, Acemoglu (2010) emphasizes the way in which the relative abundance of the production factor, including different types of labor, determines the direction of technical change.

3 Basu (2000) and Hölzl (2010) address the subtle but significant differences between the Neoclassical- and Classical-induced innovation approaches.

We followed the above studies and employed Foley & Michl's (1999) growth-distribution schedule. By adding econometrical analyses within a historical context, we revealed the endogenous feature of the bias in technical change. In particular, we cautioned that the above-referenced empirical literature measures and discusses technical progress in terms of labor productivity growth and thus explicitly omits capital productivity or implicitly assumes constant capital productivity. This practically fails to distinguish a form of Marx-biased capital-using technical change and labor-augmenting or neutral technical change. As Groll & Orzech (1990: 99) properly points out: "whereas the former imposes changes that are advantageous to the owners of the means of production, the latter, by definition, preserves the distribution of the total product between labor and capital unchanged." Hence, we drew a distinct line between biased and neutral technical change by looking at separate trends in labor and capital productivity and identified the factors driving the biases in both productivities, which will help evaluate the relevance of Marx-dynamics in technical change in Korea and clarify its implications for the current lengthy recession.

The rest of the paper is structured as follows. The next section presents a brief framework of the growth-distribution schedule and characterizes the different patterns of technical change. The third section provides the schedule in Korea and its interpretations. Sections 4 and 5 explore the bias-inducing factors and specifically discuss the deviation of capital productivity from the long-run trend during the post-crisis period. Section 6 summarizes the findings and concludes with a policy implications discussion.

2. Analytical Framework: Growth-Distribution Schedule

Following the pioneering work of Foley & Michl (1999), we consider a simple capitalist economy using only capital and labor. The production technique and its direction of change are represented in the growth-distribution schedule (hereafter "GDS"). For a given year, X is real gross output, K is net stock of non-residential fixed assets, C is aggregate consumption, I is gross investment, D is depreciation, N is the number of workers employed, W is total worker compensation, and R is net profit. Using both national income accounting identity, $X \equiv W + R + D$, and expenditure identity, $X \equiv C + I$, the following GDS is easily derived:

$$c = x - (g + d)k \quad (1)$$

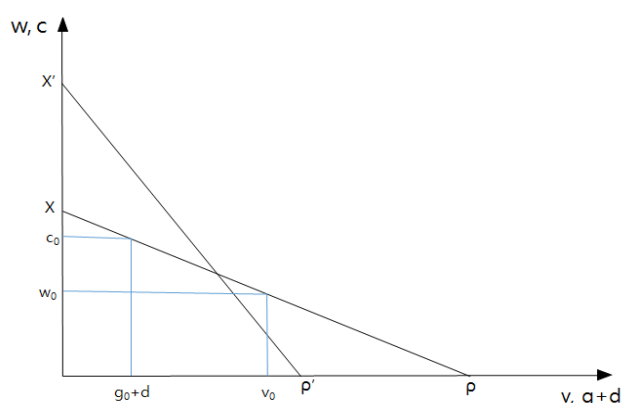
where $x=X/N$ is labor productivity, $w=W/N$ is the wage rate, $c=C/N$ is social consumption per worker, $k=K/N$ is capital per worker, $d=D/K$ is the depreciation rate, and

$g+d=I/K$ is the rate of capital accumulation. Considering the identity, $x \equiv w + vk$ where v is the gross rate of profit, we can rearrange equation (1) into (2), where $\rho = x/k$ is the output per unit of capital or capital productivity.

$$w = x(1 - (v/\rho)) \quad (2)$$

In the $(c, g+d)$ space, the schedule of (1) is a straight line with the vertical and horizontal intercepts of (x, ρ) , respectively. Additionally, in the (w, v) space, the schedule of (2) is the same straight line with the same intercepts. The schedules imply an inverse relationship between the real wages and the profit rate as well as the consumption and capital accumulation. As both schedules are mathematically identical and have an equal $-k$ slope, we can depict them graphically in the same quadrant as in Figure 1.

Fig. 1. Growth-distribution schedule, Marx-biased technical change.



The GDS movements reflect the bias in the adoption of technical change, which a combination of changes in labor and capital productivity presents. When labor productivity(x) increases, the vertical intercept shifts outward, and when capital productivity(ρ) increases, the horizontal intercept shifts outward. Accordingly, we are able to identify some common technical change patterns in the relevant literature as follows, and any pattern below can be depicted in the GDS.

For example, a pure labor-saving (Harrod-neutral) technical change that increases x while keeping ρ constant corresponds to a clockwise rotation of the GDS around its horizontal axis. Inversely, a pure capital-saving (Solow-neutral) technical change that increases ρ while keeping x constant corresponds to a counter-clockwise rotation of the GDS around its vertical axis. The other GDS shifts are relevant; a nearly equal labor- and capital-saving (Hicks-neutral) technical change that increases ρ and x alike corresponds to a near-parallel outward shift of the GDS, while a labor-saving and capital-using (Marx-biased) technical

change that increases ρ and decreases x corresponds to a clockwise pivot around the switching point in the positive GDS orthant. This final movement is illustrated from (x, ρ) to (x', ρ') in Figure 1.

As the GDS assumes a one-commodity production economy and is not free from the issues the Cambridge controversy raised, the GDS has a chance to be non-linear in the actual economies. Foley & Marquetti (2003) and Basu (2010) observe that this point poses a potential caveat to the GDS framework. We have yet to devise an alternative model that can address, for example, the problems due to capital aggregation in a non-linear GDS. However, from a pragmatic perspective, as Ochoa (1984) showed for the U.S., da Silva (1991) for Brazil, and Tsoulfidis & Rieu (2006) for Korea, all estimated GDSs are quasi-linear and display few curvatures, which justifies our simple analytic framework.

3. Historical Directions in Technical Change

In this section, we investigate the direction of bias in technical change for the Korean economy. We used the National Income at factor cost as a measure of output (X). For the real net capital stock (K), we employed the national balance sheet accounts the Bank of Korea construct using the perpetual inventory method. The capital stock excludes both inventories and non-produced assets such as land, mineral, and energy reserves. Based on the data Statistics Korea and the Ministry of Employment and Labor collected, we calculated the total number of hours worked for labor productivity denominator (L).

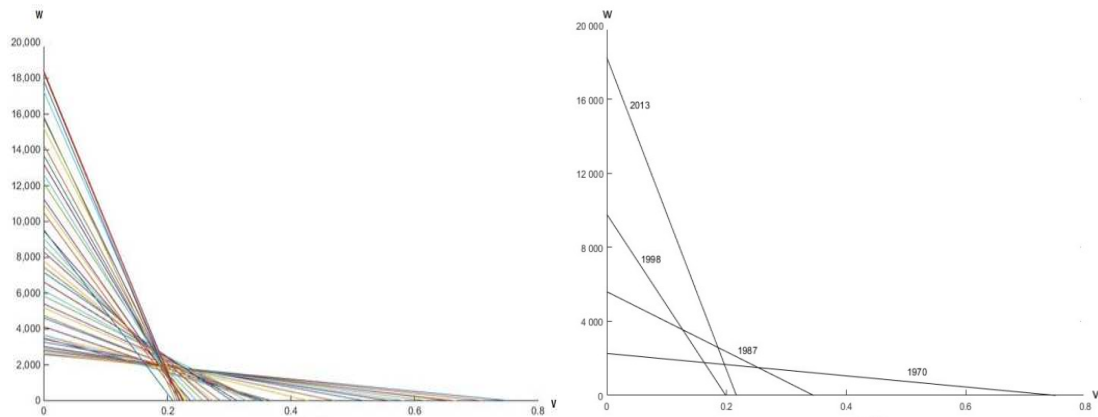
The analysis is divided into three phases: 1970-1987, 1988-1997, and 1998-2013. Both the first and second phases were periods of rapid export-led industrialization and successful catching-up, while the second period was marked by the explosive growth of labor movements as well as large conglomerates that compete in global high-technology industries. The third phase is a post-Asian crisis period characterized by the thoroughgoing liberalization of financial markets and labor market deregulation. Figure 2 presents the movement of the GDS over all three phases and the above principal moments.

Fig. 2. Growth-distribution schedule of Korea: all industries

(a) Total period

(b) Principal moments

The clockwise pivot of GDS in Figure 2 shows that the Marx-biased pattern of technical



change has been dominant for the entire period in Korea. Labor productivity has risen steadily with only a few exceptions when the economic crises occurred. The average labor productivity growth for all industries reached 4.85%. Conversely, capital productivity declined over all periods with an average growth rate of -2.79% . This long-run MBTC trend also occurred with manufacturing.

This pictured MBTC touches upon an important issue on the ascending evolution of labor productivity, which is at odds with the overall decrease of capital productivity. As Duménil & Lévy (1995) who explain technical change in probabilistic terms noted, Korea's case again confirms that technical innovation which increases both labor and capital productivity, contrary to Neoclassical claims, is intrinsically difficult to achieve. Thus, economic growth under capitalism likely strays from a balanced growth path. Besides, when constant labor share accompanies this “trajectory *à la Marx*” (Duménil & Lévy 2003), the profit rate falls. That is to say, the trajectory of the Korean economy with technical progress has been endogenously crisis-prone and inevitably has entailed class conflict to offset the tendency toward a crisis. This Marxian point is a *sine qua non*, which mainstream textbooks praising Korea's growth performance scarcely address.

As Marquetti (2003) found, a strong MBTC tendency characterizes the evolution of less-developed economies that adopted capital-intensive technology from highly developed economies. In other words, capital-intensive investments usually accompany developing countries' catching up process. With an average capital accumulation rate of over 12% during the high-growth regime in the first and second phase, the case of Korea with MBTC is the byword for dynamic but contradictory capitalist development.

Table 1. Average growth rates (%) of labor and capital productivity

Phases	All-Industry		Manufacturing	
	x	ρ	x	ρ
1970-1987	5.16	-4.21	5.75	-2.70
1988-1997	5.93	-3.68	9.47	-3.34
1998-2013	3.85	-0.58	7.39	1.79
Total (1970-2013)	4.85	-2.79	7.18	-1.24

As a side note, during the post-1998 period when the financial crisis severely hit Korea and forced it to implement IMF-imposed structural adjustment programs, the increasing speed of labor productivity began to decelerate while the decreasing trend of capital productivity slackened or grew positively over intermittent years, as shown in Table 1. That is, although the pervasive long-term pattern of technical change has been labor-saving and capital-using, its evolutionary path was uneven, depending on the short phases of capitalist development. Overall, Korea in the 21st century, with lower economic growth and overly stagnant accumulation rates, has more frequently witnessed aspects of technical progress differing from the existing trend. This new phenomenon is more pronounced in the manufacturing sector, where productivity measurement is less controversial than compared with the entire economy, including the service sector.

Will this new path in the 21st century, with increased Harrod- and Hicks-neutral technical change characteristics, be only a temporary deviation or a complete disengagement from the long-run trend of the Marx-biased pattern? To answer this puzzling phenomenon, we attempted to identify the factors that underpinned and determined the GDS pivot movement.

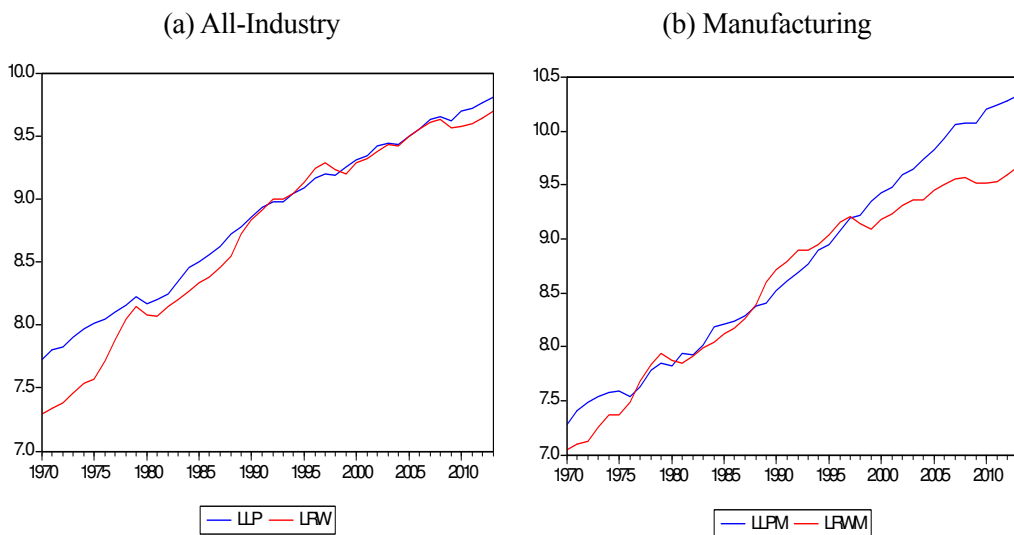
4. Relationship between Technical Change and Real Wage

Conventional wisdom has it that the combination of low wages and cheap exports drove the Korean economy's high growth during the pre-1998 period. Taking into account a cruel military dictatorship with repressive labor laws and flagrant interventions into labor disputes, such opinions carried weight. However, the invincible developmental state was involved in the labor market not only as a conflict suppressor but also as a promoter of skill formation and learning (You & Chang, 1993; Ra & Shim, 2009). For the *chaebols* who started consolidating their power in the world market, cooperation with the interventionist state was vital for gaining de facto state-underwritten credit and tax incentives, and for expanding their business to more capital-intensive industries. Hence,

keeping the wage increase in check was neither a priority nor advantageous for upgrading technologies (Seguino, 2000). In that vein, to maintain high accumulation levels, sustained and “guided” wage increases rather than low wages were more important.

Indeed, as the time series of real wages and labor productivity in Figure 3 describes, both trends displayed almost consistent positive growth. For the real wage, the total compensation per hour worked by an employee deflated by the consumer price index was used to provide a measure of the workers’ real purchasing power. Although initially very low, real wages often grew more rapidly than labor productivity for the first two phases. In particular, when democratization movements finally ended the oppressive military regime, real wage growth was spurred and peaked in the early 1990s; hence, the labor share of the value added also surged, although for a relatively short period.

Fig. 3. Time series of labor productivity and real wages



Note: LRW log-transformed real wage rate; LLP log-transformed labor productivity.

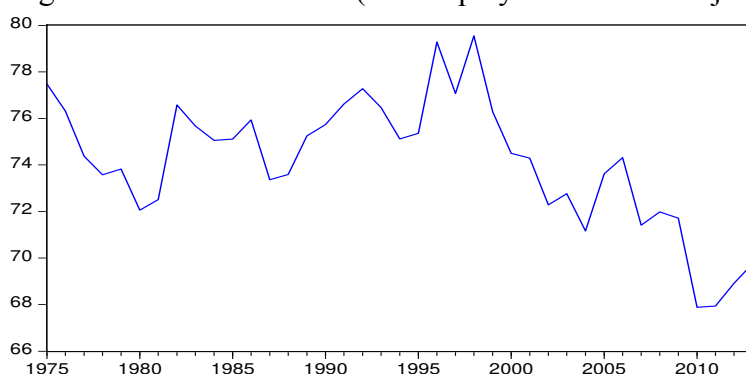
Source: Statistics Korea (www.kosis.kr), Ministry of Employment and Labor (laborstat.molab.go.kr).

Instead, labor productivity reactively increased enough to offset the shrinking profit from the wage increase. It is noteworthy that the rise in labor productivity was accompanied by the acceleration of fixed capital formation until the advent of the crisis in 1997-1998. Against the rapid rise of working class power, big conglomerates began to enlarge their vertical subcontracting and supplier networks with small and medium-sized firms, hence solidifying their monopoly power in technical innovation investment. Under the gradual change of the state-chaebol power dynamic toward the latter and freer overseas financing due to deregulation, these measures generated a mirage with another labor productivity boom that lasted until the mid-1990s, also acting as a carrot to appease the working class. After all, the case of Korea before the Asian crisis was an unusual example among

developing countries, which successfully intensified both the absolute and relative surplus value extraction in Marxian parlance.

However, with the late-1990s currency crisis, labor market liberalization began to be forced, which included the labor protection law relaxation, mass dismissal law introduction, and employment flexibility enhancement. Due to these neoliberal measures, real wage growth decelerated considerably while the productivity series showed a slightly smoother growth, which implies the deterioration of labor income shares in the functional income distribution. Actually, the labor share dropped by almost 10 percentage points during the post-crisis period (see Figure 4).⁴ This reversal was more pronounced in manufacturing, which suffered from a mass employment reduction and became more vulnerable to price competition from rivals abroad compared to the non-tradeable service sector.

Fig. 4. Labor income share (self-employment income adjusted); all industries, %



Note: Income data for adjustment is available only from 1975.

Source: Bank of Korea.

Based on the brief historical observations above, we econometrically examined the long-run relationship between real wages and labor productivity. As a relevant strategy, we applied cointegration and the Granger-causality test based on the vector error-correction

4 It is well known that labor income share more commonly used in official statistics underestimates the share of employee compensation in value added, because it calculates all income of the self-employed as capital share. However, income of the self-employed comprises both labor and capital income, and there is a significant difference between the usual labor share and self-employment-income-adjusted labor share (Gollin 2002). In particular, Korea has a 28.2% proportion of self-employed to fully employed, which is far higher than the U.S (6.8%), Japan (11.8%), and the average of OECD members (15.8%) as of 2012 (OECD, 2014). Therefore, we recalculated the labor share by omitting the operating surplus of private unincorporated enterprises (OSPUE) from the denominator (Y), which is algebraically the same as assuming the proportion of labor and capital income of OSPUE is equal to that of the rest of the economy.

model (VECM) for Korea, like Marquetti (2004) did for the U.S. and de Souza (2015) did for a panel of countries. Because unit root tests clearly show that both series are nonstationary and integrated of order one (see Appendix), we first ascertained the presence of a long-run equilibrium between the two time series by using the methodology Johansen (1991) developed. The results clearly indicated a single co-integrating vector, which implies some comovement between the two series in the long run (see Appendix). Then, we estimated the VECM as equation (3) and (4),

$$\Delta LP_t = \alpha_1 + \sum_{i=1}^p \beta_{1i} \Delta LP_{t-i} + \sum_{i=1}^p \beta_{2i} \Delta RW_{t-i} + \gamma_1 \hat{\epsilon}_{t-1} + u_{1t} \quad (3)$$

$$\Delta RW_t = \alpha_2 + \sum_{i=1}^p \theta_{1i} \Delta RW_{t-i} + \sum_{i=1}^p \theta_{2i} \Delta LP_{t-i} + \gamma_2 \hat{\epsilon}_{t-1} + u_{2t} \quad (4)$$

where LP and RW denote labor productivity and real wages, ϵ is an error correction term in a normalized form, and u is a random error term. Given that we have only 44 annual observations, a maximum lag length of four is imposed on the equations and the lag length is chosen based on the Akaike and Schwartz criterion. The optimal lags were mostly one or two, hence we reported both cases for a robustness check. Inasmuch as the existence of cointegration implies the Granger causality but does not indicate the direction of causality, we further examined both the short-run and long-run Granger causality within the VECM. The causality was obtained by testing the long-run (error correction term) and short-run (differenced explanatory variables) effects together with the joint F-statistic (Gujarati 2011: 272-274; Lütkepohl 2005: 262).⁵ That is, for equation (3), if the null hypothesis $H_0: \beta_{21} = \beta_{22} = \dots = \beta_{2j} = 0$ and $\gamma_1 = 0$ is rejected, the real wages do Granger-cause labor productivity. The symmetrical hypothesis, whether labor productivity Granger-causes real wages, is also tested in the same manner. The results are reported in Table 2.

Table 2 reports the existence of unidirectional causality from real wages to labor productivity, and the causality is stronger for manufacturing than other industries overall. The empirical verification that real wages precede labor productivity, a more precise interpretation of Granger-causality, implies that real wage increases entice capitalists, under competitive pressure from other capitalists, into implementing technological

5 This methodology is challengeable as it not only requires unit root and cointegrating rank pretests but also might be biased toward rejecting the non-causality null since cointegration implies existence of long-run causality for at least one direction. Therefore, Toda and Yamamoto's (1995) methodology which estimates augmented VAR with level variables may be a better strategy which reduces the risks of wrongly identifying the order of integration. However, as Toda and Yamamoto (1995:246) explicitly explains, when the VAR's lag length is just one as in our paper, the inefficiency caused by adding even one extra lag might be relatively large.

progress to secure their own profitability. The magnitude of such “wage-cost induced” labor productivity growth seems to be substantial given that Vergeer & Kleinknecht (2011) reported 0.31-0.39 percentage points for a panel data of OECD countries (1960-2004) and Naastepad (2006) attributed 90% of the Dutch productivity growth slowdown after 1982 to the decline in real wage growth.

Table 2. Granger-causality test between the real wage rate and labor productivity

Direction of causality		lag 1	lag 2
		Joint F-statistic	
All-Industry	RW \nRightarrow LP	4.757**	4.359**
	LRW \nRightarrow LLP	2.290*	2.601*
	LP \nRightarrow RW	1.173	1.011
	LLP \nRightarrow LRW	2.701*	2.188
Manufacturing	RW \nRightarrow LP	16.773***	11.933***
	LRW \nRightarrow LLP	3.415**	4.280**
	LP \nRightarrow RW	0.267	0.873
	LLP \nRightarrow LRW	1.093	2.723*

Note: \nRightarrow means the null hypothesis of non-causality.

* significant at 10%, ** significant at 5%, *** significant at 1%

Meanwhile, the causal direction from real wages to labor productivity runs counter to the Neoclassical marginal productivity theory, which states that wages are determined with respect to productivity. Except for variants of the efficiency wage theory, the neoclassical proposition that higher productivity will cause higher real wages lacks empirical support, at least for Korea.⁶

5. Explaining Capital Productivity Change

It is worth noting why we should proceed to the separate discussion of capital

6 Although not based on the same framework as ours, previous research for other countries such as Australia (Kumar et al. 2012) and Turkey (Bildirici & Alp 2008) also confirm the causal direction from real wages to labor productivity.

productivity changes. The direction of causality from real wages to labor productivity cannot be ascribed only to the MBTC. The causality can also be explained in the context of the Kaldor-Verdoorn effect, which suggests that aggregate demand spurred by wage share increases, more obviously in a wage-led economy, affects the learning-by-doing and division of labor leading to higher labor productivity. Similarly, the Neoclassical efficiency wage theory also suggests that higher wages attract more productive workers who rationally avoid being dismissed. That is, the econometric finding of causation from real wages to labor productivity is simply a confirmation of MBTC's necessary (but not sufficient) condition.⁷ For this reason, the factors that underpin MBTC in terms of capital productivity change merit a detailed examination; hence, we first investigated the relationship between real wages and capital productivity.

Fig. 5. Capital productivity and (log) real wage rate, 1970-2013.

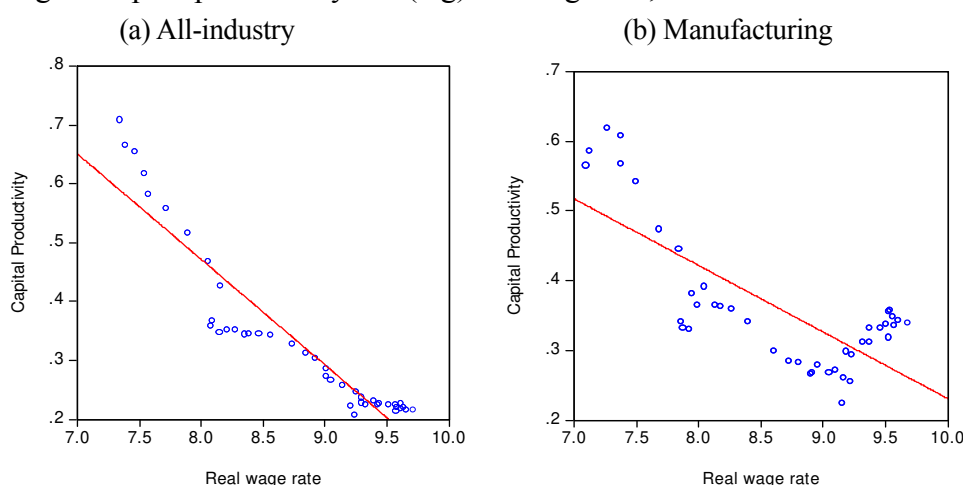


Figure 5, the scatter plot with regression line between the two variables, shows it is evident that capital productivity growth depends negatively on real wage growth.⁸ This

7 The Kaleckian models, such as You (1994) and Casetti (2003) described, successfully highlight the endogenous demand-side conditions of facilitating technological innovations, but the innovations' capital-using aspect is not addressed. Likewise, although Hein & Tarassow (2010) and Storm & Naastepad (2013) attempted to differentiate the mixed effects of technical change attributed to both the Kaleckian demand effect and the Marxian effect, their empirical estimations are limited to the change in labor productivity only.

8 We refrain from repeating the econometric inferences for capital productivity. The capital productivity series for all-industry does not have a unit root (see Appendix), as in both series of labor productivity and real wages, and the ECM specifications are not applicable due to the lack of evidence of cointegration. Hence, a more robust econometric specification against spurious regressions should employ a lengthy model, e.g., the autoregressive distributed lag model with other control variables; however, we only present several graphs for the sake of brevity and

result implies that capital-using technological progress has been adopted more frequently against the increase of workers' power, which again confirms the predominance of MBTC in the long run.

However, as mentioned, the post-crisis period saw an impressive and positive capital productivity growth, particularly in manufacturing. Capital productivity increase per se can be interpreted as an enhanced efficiency of capital in terms of an output increase realized on the basis of a given stock of capital. If such dynamism was caused, as generally conceived, by virtue of the adoption of new innovative technologies, the hypothesis of MBTC's dominance is debatable, if not untenable. Michl (1992) stresses that endogenous capital-saving technical change may emerge as the effect of learning-by-doing driven by cumulative output while the exogenous natural direction of technology is capital-using, and the opposite combination of exogenous capital-saving and endogenous capital-using technical change is also plausible. In other words, which aspect of capital productivity change will prevail depends not on a priori theorems but on empirical grounds. Hence, we explored several figures and statistics of potential factors that may have enhanced capital productivity, each of which would entail contrasting tenets from Neoclassical, Keynesian or Marxian economics.

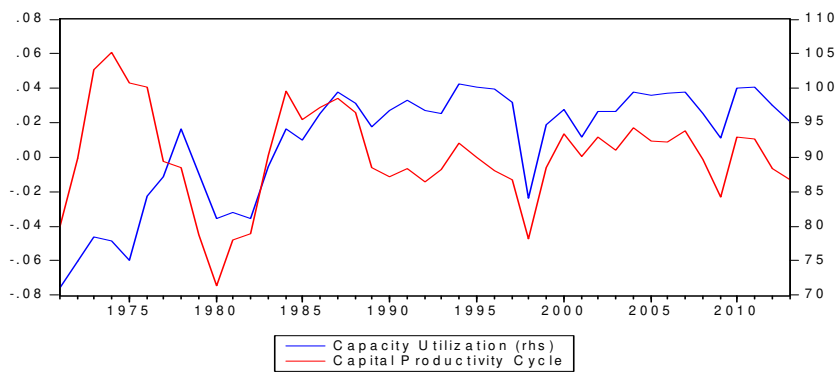
First, from the viewpoint of Neoclassical endogenous growth theory, R&D investment is critical for enhancing capital efficiency. The diffusion of innovative technologies can help an economy build new types of dynamic efficiency. Aside from methodological flaws like "setting up capital-like sectors for the production of human capital and R&D, bundling up and representing technical change through the device of treating it like a new factor of production" (Fine & Dimakou 2016:58), it is undeniable that technological advances related with so-called knowledge creation might have operated to some extent. However, examining the figures compiled in the OECD Structural Analysis database (2016), R&D intensity of high and medium-high technology manufacturers, which is calculated as R&D expenditures as a percentage of value added, rose from 10.1% in 1995 to 13.7% in 2009. Similar increments are neither uncommon among OECD economies nor comparable to those of advanced economies such as the U.S. (from 16.5% to 21.8%), the U.K. (from 11.0% to 15.2%) and Japan (from 14.2% to 22.7%), who are said to be in a Solovian steady state. Besides, the national balance sheet accounts (Bank of Korea 2015) show that, while the share of intellectual property products in total fixed assets of all corporations rose from 1.8% in 1970 to 9.9% in 2013, the share's annual growth rate has dropped from 4.8% in the pre-crisis to 2.6% in the post-crisis period. In sum, the Neoclassical orthodoxy which

intuitive obviousness.

accentuates technology diffusion, knowledge accumulation, and the like, does not persuasively explain why capital productivity appreciates during economic downturns.

Second, we traced the cyclical demand-side factor's effect on capital productivity because Figure 5 may have disclosed only the long-run trend aspect of capital productivity. It is motivated by the Kaleckian reasoning, which states that capital investment is a function of the changes in the expected profit rate and capacity utilization (Bhaduri & Marglin 1990; Hein 2008). The increase of capacity utilization (hereafter "CU"), which commonly serves as a proxy for cyclical demand,⁹ stimulates further investment, and the effect may well be reflected in capital productivity.

Fig. 6. Capacity utilization and cyclical component of capital productivity; manufacturing



Note: Capacity utilization rate's benchmark year is 2010.

Source: Bank of Korea, Author's calculation.

Hence, we plot the CU rate and the cyclical element of the HP-filtered ($\lambda=100$) capital productivity in Figure 6. Although a robust relationship between the level variables in different time periods has not been found, the cyclical series of capital productivity shows a very similar evolution to the CU rate, which means capital productivity moves procyclically.¹⁰ In other words, the role of demand-side shocks in technical change is sufficiently relevant, aside from the traditional concern of the short-run versus the long-run breadth of analysis. Consequently, temporary aggregate demand rebounds including a

9 The choice of the demand-side variable is an open issue, but we chose the CU rate as the best proxy.

The comparison with other conventional options, such as the GDP's cycle component or output gap, runs the risk of tautology because the capital productivity variable already has the output term in the numerator. Moreover, output gap estimates based on potential output are neither theoretically flawless nor officially reported in Korea.

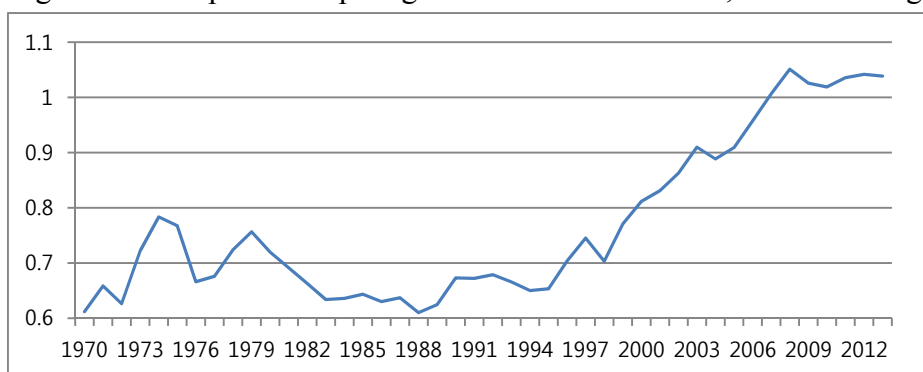
10 Schoder (2012) provides theoretical arguments as to capital productivity procyclicality for the reason that firms seek to adjust capital productivity to narrow the gap between realized and desired CU.

short boom in the mid-2000s, contributed to the rise of capital productivity, if not a complete reversal of the long-run trend.

Last, but most importantly, turning to a Marxian perspective, exploitation and class conflict dynamics are another key to puzzle out capital productivity appreciation. As inferred from the simple identity $Y/K = (L/K) \times (Y/L)$, the movement of capital productivity is the combination of capital intensity and labor productivity.

Regarding the first term (L/K) of the identity, it is bound to decrease with higher capital deepening which substitutes capital for labor. But, the annual capital deepening growth rate has almost halved from 9.33% (1987-1997) to 5.11% (1998-2013) for all industries and from 11.83% to 6.70% for manufacturing. The primary culprit that put a damper on capital deepening is the rising price of capital goods. As Figure 7 shows, although the cheap and stable price of capital goods, partly credited to the previous developmental state's resource allocation, fueled massive capital-intensive investment, the relative price to the price of output since the Asian crisis has steeply risen.

Fig. 7. Relative price of capital goods to the GDP deflator, manufacturing



Source: Bank of Korea, author's calculation.

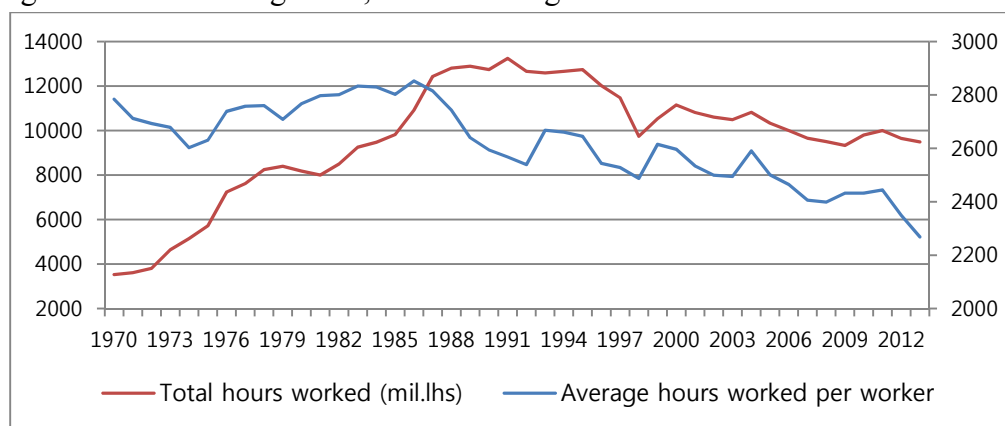
The capital goods price hike clearly facilitates investment with capital-saving rather than capital-using technologies. But more expensive capital goods do not fully explain the decline in capital deepening. As implied by the data shown in Figure 4, profit income share soared beginning with the crisis. The ratio of corporate saving to disposable income also increased drastically from 2.9% (1997) to 11.0% (2010). The corporate saving glut stemmed from surging operating surplus as well as benefits from radical tax breaks by the neoliberal state, and reduction of financial costs in a long, low-interest environment, etc. That is, it's unclear whether capitalists could ill afford to increase capital-intensive investment only owing to cost burden of capital goods. Rather, the slowdown in capital deepening also reflects worker's non-threatening bargaining power and moderated wage

increase which contributed to the reduction of firms' incentives for capital-using technologies.¹¹

As for the second term (Y/L) of the identity, the issues are more delicate. Labor productivity growth sizably contributed to sustaining and raising capital productivity for this period. Interestingly, for the period 1998 to 2013, though not appreciable as a pre-crisis period, average labor productivity growth per annum in manufacturing was over 7.4%. The record is noteworthy because it was achieved without vigorous capital deepening as explained above.

Given that the labor productivity series described in this paper was constructed as output per total hours worked, the labor productivity increase was primarily due to the working hours reduction demanded by Korean workers' strenuous struggle and international pressure, which crucially resulted in the 40-hour workweek system adoption in 2004. Figure 8 shows there has been a gradual decline in average hours worked per worker since the mid-1980s, although Korea is still not free from the infamy of recording the first or second longest working hours among OECD economies.

Fig. 8. Annual working hours; manufacturing.



Source: laborstat.molab.go.kr (Ministry of Employment and Labor).

On the other hand, the relatively high labor productivity growth reflects intensified worker exploitation. It became easier for firms to extract labor productivity increases by further expanding the use of temporary workers and low-wage subcontractors. Labor market flexibility reforms for over a decade have not only greatly reduced workers' ability

11 Other reasons for the remarkable discrepancy between corporate saving and investment can be deduced from various factors; for example financialization (Stockhammer 2004) and monopoly (Foster and McChesney 2012). To verify these hypotheses in detail is beyond the scope of this paper.

to negotiate higher wages and obtain employment stability but also frustrated worker solidarity. As a result, Korea has the highest incidence of low-paid work among full-time workers and the third-highest level of earnings dispersion, just below the U.S. and Israel as of 2011 (OECD 2013: figure 3.4). Moreover, temporary employment accounts for 22.4% of total dependent employment in Korea—the fourth largest among OECD members. Such workers are least likely to move into permanent employment among their counterparts in 15 other OECD members, which is true over both one-year (11.1%) and three-year (22.4%) horizon (OECD 2013: table 3.7).

It is doubtful whether such cost-cutting strategies as nonregular employment and external labor flexibility are sustainable for long-run economic growth (Lucidi & Kleinknecht 2010).¹² But these organizational changes deserve to be called “effort-biased technical change” using Green’s (2007) terminology, as they demand more highly-committed and more productive “human capital” by using temporary workers and contractors in the absence of substantial capital deepening. After all, it was the highly strengthened power of capitalists vis-à-vis workers under the prolonged stagnation that enabled the contradictory capital productivity appreciation. In theory, the bias of technical change does not presuppose a high or low growth rate of capital intensity. However, as in our case, the U.S. (1982-1997), Argentina (1982-1994) and Chile (1964-1989) together show that Hicks-neutral technical change, where both labor productivity and capital productivity rise, occurred when capital deepening was lethargic (Mohun 2009; Mendoza 2007). And they have in common that those eras are marked by the relative weakening or defeat of the working class. It suggests that although the physical outcome of technical change may be neutral in the strict sense of the word, the driver of direction in technical change is far from being “neutral” as the class conflicts center on the adoption of specific technologies.

5. Concluding Remarks

This paper empirically examined the bias of technical change and investigated its determinants in Korea. The endogenous direction of technical change has been a rather-neglected topic in Neoclassical growth literature, which is especially true for Korea who achieved extremely rapid growth. Instead, we used the growth-distribution schedule to show that the labor-saving and capital-using pattern have been the dominant type of technical progress. The relationship between technical change and real wage growth via

12 Recently, even IMF researchers (Aoyagi & Ganelli 2013) propose reducing the labor market duality and increasing wages to move toward higher growth.

the evolution of labor and capital productivity verified the historical direction of technical change against the rise and fall of the working class, which is the rationale behind the MBTC. Furthermore, the direction in technical change during the post crisis period suggests that sluggish wage growth with undermined workers' power ironically contributes to attenuating the incentives for technological progress. Likewise, the contemporary deviation of capital productivity from the long-run trend of MBTC is not attributable to the vitality of new technological innovations, but rather is the reflection of class dynamics over extracting productivity under weaker capital deepening.

Our study's policy implications are straightforward. The alternative growth strategy against the contemporary secular recession should embrace policies that favor increases in real wages and wage shares. Taking MBTC into consideration, the recent deterioration of labor unions and their bargaining power prolongs the recession by deterring technical progress as well as by only stifling effective demand. In this regard, our findings suggest that higher wage-induced technical innovation under stable employment conditions will offer the tipping point for economic recovery with decent work.

However, two points are worth mentioning regarding growth dynamics. First, the dominance of the endogenous MBTC pattern may forecast a gloomy picture for workers because higher real wage growth may generate a lower employment by accelerating the worker-replacing technology. MBTC's job-loss potential can primarily reduce the wage-fueled growth effects that are strongly underlined by the recent Post-Keynesian literature. Although the question of whether such trade-offs will be substantively significant in Korea and other specific economies should be explored in future research, the effect of wage increase on aggregate demand may be overestimated if we pay scant attention to the aspects of technical change that appear in employment.¹³ Second, as long as the trend of MBTC with a constant or rising labor share logically incurs the tendency for the rate of profit to fall, an intense class struggle from a capitalist counter-attack is inevitable, for which the Korean economy has been no exception as we have shown. In other words, the dominance of MBTC allows little room for class compromise or cooperative capitalist growth that is suggested by naive Keynesian wishes. These will be knotty points for the pro-labor economics camps to settle, when designing alternative growth policies.

13 Storm and Naastepad (2013:109) correctly notes, "the higher is the sensitivity of productivity growth to real wage growth, the more limited will be the strength of the wage-led nature of aggregate demand."

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Appendix

Table A1 Unit Root Tests

Variables		LP	LLP	RW	LRW	CP
All-Industry	ADF Levels	-1.152	-2.131	-2.395	-2.378	-6.895***
	First Difference	-9.427***	-6.725***	-2.568*	-3.953***	-4.241***
	PP Levels	-1.804	-2.146	-2.372	-2.433	-5.409***
	First Difference	-8.705***	-6.729***	-4.447***	-3.765***	-4.343***
Manufacturing	ADF Levels	2.368	-2.429	-2.660	-2.370	-2.263
	First Difference	-7.437***	-6.961***	-2.706*	-3.971***	-4.498***
	PP Levels	-0.061	-2.429	-2.055	-2.089	-2.139
	First Difference	-6.637***	-6.966***	-3.459*	-3.912**	-4.622***

Note: L stands for logarithm; RW real wage rate; LP labor productivity; CP capital productivity; ADF Augmented Dickey-Fuller test; PP Phillips-Perron test.

* significance at 10 percent; ** significant at 5%, *** significant at 1%.

Table A2. Johansen bivariate cointegration

Hypothesized number of cointegrating equations		λ -trace Statistic	λ -Max Statistic
All-Industry	LP-RW	None	22.018**
		At most 1	2.120
	LLP-LRW	None	13.675*
		At most 1	1.149
Manufacturing	LP-RW	None	23.611**
		At most 1	1.547
	LLP-LRW	None	17.431**
		At most 1	1.665