

Is there a tendency for the rate of profit to fall? Econometric evidence for the U.S. economy, 1948-2007

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Abstract: The law of the tendential fall in the rate of profit has been at the center of theoretical and empirical debates within Marxian political economy since the publication of Volume III of Capital. An important limitation of this literature is the relative paucity of modern econometric investigations of the behavior of the rate of profit. The central objective of this paper is to remedy this lacuna. We investigate the properties of the profit rate series utilizing the methods of time series econometrics. The evidence suggests that the rate of profit is non-stationary. We also specify a test Marx's law of the tendential fall in the rate of profit with a novel econometric model that explicitly accounts for the counter-tendencies and their time series properties. We find weak evidence of a long-run downward trend in the general profit rate for the US economy for the period 1948-2007.

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1. Introduction

Marx's claim in Volume III of *Capital* that there is a tendency for the general rate of profit to fall with the development of capitalism, referred to as the law of the tendential fall in the rate of profit (LTFRP), spawned an enormous literature often marked by bitter controversy and fruitful debate (Dobb, 1939; Sweezy, 1942, Gilman, 1957; Okishio, 1961; Mage, 1963; Shaikh, 1978; Wolff, 1979; Mandel, 1980; Roemer, 1981; Bowles, 1985; Foley, 1986; Michl, 1988; Shaikh, 1992; Duménil and Lévy 1993, 1995; Foley and Michl, 1999; Wolff, 2001; Dumenil and Levy, 2002a, 2002b; Wolff, 2003; Kliman, 2009).¹ Marx asserted that the LTFRP was “the most important law of political economy” since it demonstrated that capitalism’s main historical strength – technological progressivism – creates barriers for its primary motor, capital accumulation. Thus, Marx thought that the LTFRP “forms the mystery around whose solution the whole of political economy since Adam Smith revolves...” (Marx, 1993, chapter 13).

The theoretical strand of the subsequent Marxist literature has focused on understanding the possible causes behind the LTFRP.² Recall that the rate of profit, in Marx (1990), is defined as $r = s/(c + v) = (s/v)/(1 + c/v) = ek$, where r represents the rate of profit, s denotes surplus value, v denotes variable capital, c represents constant capital, e denotes the intensity of exploitation (also called the rate of surplus value) and $k = 1/(1 + c/v)$ denotes the composition of capital (Foley, 1986). Hence, the rate of growth in r equals the sum of the growth rates of k and e . The early debate was focused on several crucial issues. The first point of contention related to

¹This list is representative. We make no claims about completeness or comprehensiveness.

²We are concerned with an investigation of the long-run tendencies. Hence, we do not refer to a separate strand of the literature, initiated by Weisskopf (1978), which studies cyclical fluctuations in the rate of profit.

a hypothesized secular fall in the composition of capital with the development of capitalism, *i.e.*, whether the increasing technical composition of capital translated into an increase in the value composition of capital.³ The second issue centered on whether an increase in the intensity of exploitation is swamped by a fall in the composition of capital, thereby countering the tendency of the rate of profit to fall (Moseley, 1991). A third issue relating to choice of technique was added to this long-standing debate by Okishio's (1961) claim to have disproved the LTFRP.

Accordingly, the subsequent theoretical literature can be fruitfully classified with reference to Okishio (1961) into the following strands.⁴ The first strand accepts the validity of the so-called Okishio Theorem, which is understood as having “proved” that the LTFRP can never emerge as a significant tendency in a capitalist economy with profit-maximizing entrepreneurs and viable technical change; prominent scholars in this strand include Romer (1981), Bowles (1985) and others. The second strand rejects the validity of the so-called Okishio Theorem *in toto* and instead believes that there is a secular tendency for the rate of profit to fall with capitalist development; prominent scholars in this strand are Shaikh (1978, 1987, 1992), Kliman (2007, 2009), Rosdolsky (1977) and others. The third strand conditionally accepts the validity of the so-called Okishio Theorem, arguing that the key assumption of fixed real wages does not characterize the actual evolution of capitalism. Neither a secular tendency for the profit rate to fall nor a secular tendency to increase can be *a priori* associated with capitalist development;

³Marx utilized several different concepts of the composition of capital in his analyses. The technical composition of capital referred to the ratio of the mass of the means of production employed and the mass of labor necessary for their employment. In modern parlance, the technical composition of capital can be interpreted as the ratio of the stock of capital to the number of workers. In contrast, the value composition of capital referred to the ratio of constant capital to variable capital or c/v . Finally, the composition of capital k is a term used by Foley (1986); k is a transformation of the value composition of capital.

⁴This classification is for the purposes of organizing our investigations. We make no claim of completeness or comprehensiveness.

prominent scholars in this strand are Foley (1986), Michl (1988), Moseley (1991), Duménil and Lévy (1993, 1995), Foley and Michl (1999), Duménil and Lévy (2003).⁵

Instead of engaging with this rich theoretical debate in detail, this paper addresses a different but related question. What is the statistical evidence regarding the tendency of the general rate of profit to fall in the U.S.? The empirical strand of this vibrant literature of course recognizes the importance of this issue but does not generally exhibit a depth and sophistication comparable to the theoretical literature. A major lacuna has been the dearth of modern econometric inquiry to inform empirical analyses.⁶ A preponderance of empirical studies utilize *only* exploratory techniques (*e.g.*, visual inspection of time series plots) in order to infer trends in the rate of profit (Gilman 1957; Wolff 1979, 2001, 2003; Duménil and Lévy, 1993, 1995, 2002a, 2002b). While visual and exploratory techniques can be valuable starting points of empirical research, it is necessary to apply modern time series econometrics for investigating trends in the rate of profit (*e.g.*, an investigation of the time-series properties of the general rate of profit) and recognize that failure to consider the postulated counter-tendencies as covariates perhaps leads to invalid conclusions about the trend. In our view, Marx did not claim that the observed rate of profit will have a secularly declining trend—the LTFRP operates at a high level of abstraction. He was careful to refer to the declining trend in the rate of profit as a “tendency” and to explicitly

⁵ Returning to his work 40 years later, Okishio (2001) accepted that the key assumption of constant real wages is unrealistic. We would like to thank Iren Levina for bringing this point to our attention.

⁶ To the best of our knowledge, Michl (1988) is an exception since he appropriately utilizes techniques suitable to the econometric milieu of the 1980s. However, the econometric specification of Michl (1988) does not consider the counter-tendencies as covariates.

incorporate significant “counteracting influences” into his analysis.⁷ We address this lacuna in the empirical literature on the LTFRP.

The remainder of this paper proceeds as follows. We briefly recount Marx’s argument about the LTFRP in section two. Section three reviews the sparse heterodox and orthodox literature on the econometrics of the profit rate. Sections four and five detail the econometric analysis, findings and data set. The final section offers our conclusions.

2. Marx’s argument

Before proceeding further, let us briefly recall Marx’s simple and powerful argument about the LTFRP as outlined in Volume III of *Capital* (Marx, 1993). Marx noted that the driving force of capitalism is the relentless search for surplus value. The early phase of capitalism is generally characterized by a drive for increasing extraction of *absolute* surplus value, *i.e.*, increasing the length of the working day and holding the real wage rate constant. In contrast, the later phase is generally characterized by an increase in the extraction of *relative* surplus value, *i.e.*, reducing the social labor time required to produce the consumption basket of the workers and holding constant the length of the working day. This outcome occurs in the course of labor’s struggle against capital and in particular following an important victory by labor that sets an upper limit to the length of the working day—although labor is of course forced to continue to fight to defend this gain. Thereafter, the search for surplus value primarily takes the form of the drive to increase extraction of relative surplus value and thus to increase the productivity of social labor.

⁷ Referring to the “steadily falling general rate of profit”, Marx asks his readers to remember that “this fall does not present itself in such an absolute form, but rather more in the tendency to a progressive fall.” (Marx, 1993, p. 319).

The drive to increase extraction of relative surplus value is at the heart of the enormous technological dynamism of capitalism compared to earlier modes of production.

Competition between capitalists induces reductions in the costs of production and thereby increases extraction of surplus value, frequently via labor-saving technical change. In other words, capitalists increasingly utilize non-labor inputs in the course of their efforts to reduce the costs of production. Note that an oft neglected dimension of the replacement of workers with machines is an increase in the power of the capitalist class and their retinue to control the production process. The contradiction between labor and capital manifests itself not only as a struggle over the division of the value added between wages and profits. This fundamental contradiction is also manifest as a struggle to control aspects of the production process like intensity and pace of labor; working conditions relating to safety of workers; recess frequency and duration; pace and direction of technological change and so forth. The constant tussle between labor and capital to control aspects of the production process is as old as capitalist social relations. Mechanization, therefore, is a potent tool in the hands of the capitalist class for their conflict with labor. A machine, after all, is much easier to dominate than a recalcitrant worker. This political dimension of mechanization was highlighted by Marx in his discussion of skilled workers and engineers in England (p. 563, Marx, 1990) and remains valid today.

This increasing mechanization of the production process enormously increases the productivity of labor and facilitates the extraction of larger amounts of relative surplus value. This increasing replacement of labor with non-labor inputs is reflected in a rise of the share of total capital outlays supporting constant capital in relation to variable capital. Consequently, what Marx

called the organic composition of capital rises and there is a reduction in the amount of labor available for exploitation by capital per unit of capital outlay. If the rate of surplus value remains constant, this fall in the composition of capital can lead to a fall in the rate of profit. Thus:

The progressive tendency of the general rate of profit to fall is, therefore, just an expression peculiar to the capitalist mode of production of the progressive development of the social productivity of labor. This does not mean to say that the rate of profit may not fall temporarily for other reasons. But proceeding from the nature of the capitalist mode of production, it is thereby proved a logical necessity that in its development the general average rate of surplus-value must express itself in a falling general rate of profit. Since the mass of the employed living labor is continually on the decline as compared to the mass of materialized labor set in motion by it, i.e., to the productively consumed means of production, it follows that the portion of living labor, unpaid and congealed in surplus-value, must also be continually on the decrease compared to the amount of value represented by the invested total capital. Since the ratio of the mass of surplus-value to the value of the invested total capital forms the rate of profit, this rate must constantly fall (Marx, 1993, chapter 13).

Having outlined an argument leading to the conclusion that there exists a tendency for the rate of profit to decline over time, Marx immediately noted the existence of powerful “countertendencies” in real capitalist economies. Such countertendencies temporarily dampen or reverse the tendency of the rate of profit to fall. In particular, there are five countertendencies that Marx mentions: (1) the increasing intensity of exploitation of labor, which could increase the rate of surplus value; (2) the relative cheapening of the elements of constant capital; (3) the deviation of the wage rate from the value of labor-power; (4) the existence and increase of a relative surplus population; and (5) the cheapening of consumption and capital goods through imports. Marx also mentioned an increase in share capital as a sixth counteracting influence. Yet the relationship between share capital and the rate of profit is not clear and therefore we abstract from this variable, following Foley (1986).

The aforementioned countertendencies mitigate the tendency for the rate of profit to fall. Hence, these covariates must be explicitly incorporated into an (econometric) analysis and their effects on the trend of profitability must be controlled in order to arrive at a reasonable conclusion about the hypothesis that the rate of profit displays a statistically significant and declining trend over time. If a time series plot of the general rate of profit or its natural logarithm does not display a negative time trend, such a finding would not amount to evidence against Marx's hypothesis. Moreover, an analysis of the regression of the general rate of profit or its natural logarithm on a deterministic time trend is not a sufficient test of Marx's hypothesis.

3. Literature Review

In this section, we review the sparse literature on the econometrics of the profit rate with an emphasis on the issue of nonstationarity. The importance of the issue of nonstationarity can be best understood by looking at Michl (1988), the work closest to our paper. Michl (1988) tested for the presence of a negative time trend in a profit rate series within a regression framework. He recognized the importance of the countertendencies in the analysis of the LTFRP and hence offered a particularly illuminating discussion of the relative price of capital. Michl (1988) tested for the presence of a negative trend in a profit rate series by borrowing the methodology of Feldstein and Summers (1977); the latter were responding to the finding of Nordhaus (1974) that there is a declining trend in the rate of profit. While the conclusions of Nordhaus (1974) were based on visual inspection of the series rather than formal statistical tests, Feldstein and Summers (1977) tested the claim about a falling rate of profit within a regression framework. Specifically, Feldstein and Summers (1977) regressed their profit rate series on a deterministic trend, controlled for cyclical fluctuations with various measures of capacity utilization and

accounted for serial correlation with the Cochrane-Orcutt method. Feldstein and Summers (1977) found the coefficient on the time trend to be statistically insignificant. Michl (1988) reported similar results on a differently constructed profit rate series.

However, the econometric analysis of Feldstein and Summers (1977) and Michl (1988) suffers from the problem of nonstationarity. If the dependent variable (*e.g.*, rate of profit) or a covariate (*e.g.*, capacity utilization rate) were nonstationary, then this problem would invalidate their statistical inferences. Yet the econometric study of nonstationary time series was given a solid foundation only towards the end of the 1980s with the pioneering work of Granger (1983), Phillips (1986) and Engle and Granger (1987). This methodology was not available to Feldstein and Summers (1977) and had not been incorporated into econometric practice at the time of Michl (1988).⁸ Our analysis of the time series properties of the general rate of profit supports the finding of nonstationarity. In formal statistical tests, discussed later in this paper, we fail to reject the null hypothesis of a unit root at standard levels of significance.

Our finding of nonstationarity suggests that the conclusions of Feldstein and Summers (1977) and by extension Michl (1988) ought to be revisited. Since the profit rate and several countertendencies are nonstationary random variables, a proper econometric treatment of Marx's hypothesis in a regression framework requires utilization of the methodology of nonstationary analysis. Indeed, three aspects of our empirical approach are noteworthy: we control for the effects of the countertendencies, explicitly account for nonstationary random variables and

⁸ As Hamilton (1994, pp. 562) observes, Blough (1992) demonstrated that a Cochrane-Orcutt GLS regression is asymptotically equivalent to a differenced version of the original regression if the original regression was a spurious regression. Thus, with the benefit of hindsight one might argue that the standard errors in Feldstein and Summers (1977) and Michl (1988) are asymptotically valid. But this still leaves the issue, if one is interested in testing Marx's hypothesis, of including the counteracting tendencies in the regression.

utilize cointegration analysis for valid statistical inference. To the best of our knowledge, these issues have not been adequately addressed in the existing literature on the econometrics of the profit rate.

4. Time Series Analysis of the Rate of Profit

4.1. Long Waves in the Rate of Profit

A time series hypothesized to have a unit root will display significant persistence. Persistence in such a time series imparts the character of so-called long waves. If such a series starts to decline, then this decline continues for a considerable period of time. Moreover, the series persists at low levels before beginning a reverse movement. Similarly, after beginning an ascent, the series continues its upward movement, again, for a considerable number of periods. Accordingly, the observation of long waves in the series would be consistent with the hypothesis of nonstationarity. Figure one plots the general rate of profit for the U.S. economy and its Lowess trend (Cleveland, 1979) for the period 1869-2007, utilizing data from Duménil and Lévy (1994, 2009).⁹ Note that the Duménil and Lévy series is the longest consistent and reliable series of the general rate of profit for the U.S. economy.

[Figure 1]

The Lowess trend in the profit rate series indeed displays a pattern of “long waves.” There is a declining trend in the general rate of profit from the mid-1860s to the mid-1910s. Thereafter, the

⁹ We use the default value of the “smoother parameter” in the function “lowess” available in the open source statistical package R (<http://stat.ethz.ch/R-manual/R-patched/library/stats/html/lowess.html>) for constructing the Lowess trend in the profit rate series; the default smoother value is 0.66.

series displays an upward trend till the early 1960s, followed by another round of declines until 2007.

Evolution of the observed profit rate, as opposed to its trend, can be delineated into four phases. In phase I, we observe a contraction during the period 1869-1894. This contraction coincides with the Depression of the 1890s. In phase II, which coincides with the period from 1894 until the onset of the Great Depression, there is no strong trend but there are minor period cycles. In phase III, there is a substantial contraction coincident with the Great Depression and a substantial expansion coincident with WWII. In phase IV, the rate of profit contracts till about the early 1980s and is followed by an expansion. Thus, the series displays considerable persistence and plausible to suppose that there is a stochastic trend in these data.¹⁰ Interestingly, the evidence in this section conforms to Mandel's (1980) and Shaikh's (1992) conjecture about “long waves” in the general rate of profit. How these long waves in the rate of profit is related to the long waves of aggregate economic activity is, of course, a separate issue, one that we do not investigate in this paper.

4.2. The Box-Jenkins Approach

This section reports the findings of a statistical analysis of the rate of profit utilizing the Box-Jenkins strategy for model selection. The Box-Jenkins approach to time-series analysis consists of three analytical stages: model identification, model estimation and diagnostic testing.

Fundamentally, the aim of the Box-Jenkins procedure is to approximate the true data generating process. Since a Ljung-Box test rejects the null hypothesis that the profit rate series, and its

¹⁰ Does the seeming absence of a deterministic time trend in the profit rate series, as evidenced by a visual inspection of the profit rate time series plot, imply an empirical refutation of the LTFRP? We think not.

natural logarithm, are white noise at conventional levels of significance, we proceed with an investigation of the data generating process.

In order to identify a tentative model, consider figures two and three. Figure two displays the lag plots for the rate of profit while figure three shows the sample autocorrelation function (ACF) and the sample partial autocorrelation function (PACF). In figure two, each pane shows a bivariate scatter plot of r_t against r_{t-k} for $k \in \{1,2,3,4,5,6\}$ where r_t denotes the rate of profit.¹¹ For example, the pane in the upper-left shows the scatter plot of r_t against r_{t-1} and initially suggests a strong correlation. Similarly, the pane in the first row and second column suggests that a correlation exists between r_t and r_{t-2} but this correlation is somewhat weaker.

[Figure 2]

In figure three, the ACF shows the sample correlation coefficients between r_t and r_{t-k} . In other words, the sample ACF plots the estimated coefficients obtained from a bivariate regression that fits a line through the scatterplots in each pane of figure two with ordinary least squares (OLS). The dashed lines indicate the bounds for statistical significance at the ten percent level. Note that the long decay of the sample autocorrelation function suggests that this series is either a stationary autoregressive process with a root near unity or is non-stationary. An examination of the sample ACF for the first differences, which we have not reported, is consistent with the hypothesis of nonstationarity and there is good evidence that the first differences are white noise.

¹¹ In this paper we draw on an excellent data set prepared by Gerard Duménil and Dominique Lévy. This data set was first used in Duménil and Lévy (1993), and details of the data construction were provided in Duménil and Lévy (1994). Subsequently, the data set has been updated till 2009 and the latest version is available online here: <http://www.jourdan.ens.fr/levy/uslt4x.txt>. Refer to the data appendix for some additional details.

An estimated partial autocorrelation function shows the estimated coefficient obtained for demeaned r_{t-k} when k lags of the demeaned variable are included in a regression without a constant (Enders, 2010, pp. 65-69). Observe that only the first lag is statistically significant in the PACF and this suggests that the data generating process does not include moving average terms. Thus, the identification stage of the Box-Jenkins procedure suggests that a good model for this series is an autoregressive integrated moving average process with one autoregressive lag and first order integration, *i.e.*, ARIMA(1,1,0).

[Figure 3]

In order to be conservative, however, we begin with the inclusion of three lags. Recall the mathematical form of an ARMA(3,0) model:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \beta_2 r_{t-2} + \beta_3 r_{t-3} + \varepsilon_t$$

where ε_t is assumed to be i.i.d. $(0, \sigma^2)$. Since the maintained hypothesis is that the rate of profit is I(1), first differencing yields an estimating equation for ARIMA(3,1,0)

$$\Delta r_t = \beta_1 \Delta r_{t-1} + \beta_2 \Delta r_{t-2} + \beta_3 \Delta r_{t-3} + u_t$$

Note that $\beta_2 = \beta_3 = 0$ and $\beta_1 = 1$ are the restrictions for a random walk with drift. In the case of a pure random walk, we see that $\beta_0 = \beta_2 = \beta_3 = 0$ and $\beta_1 = 1$ and hence, $r_t = r_{t-1} + \varepsilon_t$.

The maximum likelihood estimates for the parameters of various plausible ARIMA models are reported in table one. In accordance with the results of the identification analysis, our maintained hypothesis is that the data generating process is ARIMA(1,1,0). Nevertheless, caution dictates that an array of plausible models be considered in order to avoid specification errors.

[Table 1]

To facilitate model selection, table one also reports the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The AIC and BIC are goodness of fit statistics that penalize overparametrized models. Accordingly, a smaller AIC or BIC implies a better model in the sense that the model is more parsimonious. Table one therefore suggests that the true model is a random walk. This finding suggests that a revision of the maintained hypothesis is warranted. Our new maintained hypothesis is that the data generating process is a random walk. We test the new maintained hypothesis $H_0: \beta_0 = \beta_2 = \beta_3 = 0$ against the two-sided alternative with a likelihood ratio test but $\chi^2 = 0.42$ and we cannot reject the null hypothesis. This additional evidence supports the view that the true model is a random walk.

Finally, we conduct diagnostic tests of the null model by subjecting the residuals to a battery of tests in order to verify that the model is well-specified. In a well-specified model, the residuals are white noise and normally distributed. The evidence supports the hypothesis that ARIMA(0,1,0) is well-specified. The Ljung-Box test fails to reject the hypothesis that the residuals are white noise. The Shapiro-Wilk and Jarque-Bera tests of normality, furthermore, favor ARIMA(0,1,0). Finally, note that we conducted unit root tests and summarize the results in table two where we fail to reject the null of unit root for the profit rate.¹² In other words, we find evidence of a stochastic trend in the rate of profit series for the U.S. economy for the period 1948-2007. Having established the statistical properties of the profit rate series for the US

¹² In Table 3, we also report results of unit root tests for the countertendencies. We discuss the results of the unit root tests for the countertendencies later in the paper.

economy, let us now turn to an econometric investigation of Marx's hypothesis about the LTFRP.

[Table 2]

5. Econometric Analysis and Findings

5.1. The Econometric Model

Marx's hypothesis about the tendency for the rate of profit to fall, outlined in Volume III of Capital (Marx, 1993) and summarized in Sweezy (1942) and Foley (1986), is remarkably well-suited for a restatement in the language of modern econometrics. Hence, the hypothesis is amenable to rigorous empirical testing with modern statistical tools. In other words, Marx's hypothesis can be restated as follows. Under capitalism, there is a tendency for the rate of profit to fall *after controlling for* the countertendencies. This hypothesis can be immediately formulated into a time-series regression framework with the counteracting tendencies operating as regressors, as outlined in this section.¹³

To test Marx's hypothesis about the LTFRP, therefore, we use the following econometric model:

$$\ln(r_t) = \alpha + \beta t + \gamma_1 z_{1t} + \gamma_2 z_{2t} + \gamma_3 z_{3t} + \gamma_4 z_{4t} + u_t \quad (3)$$

where α is a constant, u_t is the error term, r_t is the rate of profit, z_{1t} is a measure of the intensity of exploitation of labor by capital, z_{2t} is a measure of the deviation of the wage rate from the value of labor-power, z_{3t} is a measure of the overpopulation in the economy, z_{4t} is a measure of the relative price of constant capital and t represents a deterministic time trend. This specification explicitly considers the counteracting influences expected to temporarily reverse the tendency of the rate of profit to fall.

¹³ Note that we are combining the second and fifth counteracting influence into one.

The crucial issue, of course, is to test whether the coefficient on the time trend is negative. Thus, one would like to test the following null hypothesis

$$H_0: \beta = 0 \tag{4}$$

against the one-sided alternative

$$H_1: \beta < 0; \tag{5}$$

if the null is rejected then that would provide evidence in favor of Marx's hypothesis.¹⁴

5.2. Data

To conduct a valid statistical test of Marx's hypothesis, this paper utilizes a data set constructed by Gérard Duménil and Dominique Lévy (Duménil and Lévy, 1994, 2009) augmented with data from other sources, and focusing on the total *private economy* for the period 1948-2007. The natural terminus of the estimation sample is 2007 in view of the fact that 2007 marked the start of a significant economic crisis of global capitalism. Moreover, the starting point of our estimation sample is determined by the fact that observations for our measure of relative overpopulation begin in 1948.

The dependent variable in the regressions is the logarithm of the profit rate, r_t , with the latter taken directly from Duménil and Lévy (1994, 2009). The profit rate is defined by Duménil and Lévy as the ratio of (a) the flow of profit measured as net domestic product *less* the wage bill to (b) the net stock of fixed capital valued at replacement cost. Among the four covariates, apart from the time trend and the constant, two are stationary (*i.e.*, intensity of exploitation and

¹⁴ In this paper we adopt methods of classical statistical inference; an alternative would be to explore Bayesian methods. We leave this latter route for future research.

deviation of real wage from the value of labour power) and two are stochastically trending (*i.e.*, relative surplus population and relative price of capital). We discuss these variables in that order.¹⁵

We construct a measure for the intensity of exploitation, z_{1t} , to be a deviation of the productivity of labor in a particular year from its long-term trend. Labor productivity is defined as the ratio of real net domestic product (in chained 2005 millions of dollars) and the number of hours worked. Both variables are directly taken from the data set of Duménil and Lévy (1994, 2009). Note that the long-trend is extracted from the labor productivity series by an application of the Hodrick-Prescott filter with a smoothing parameter of 6.25 since the data is of an annual frequency (Ravn and Uhlig, 2002).

The intuition behind this measure of the intensity of exploitation rests on the idea that the time series in labor productivity can be decomposed into two components: (a) a component that responds to technological changes in the production process and (b) a component that arises due to variations in the intensity of labor exploitation *independent of technology*. Hence, we interpret (b) as a surrogate for the intensity of exploitation. Variations in the intensity of labor exploitation independent of technology might be affected by, among other things, shifts in the collective power of labor *vis-à-vis* capital, regulations governing working conditions, the state of the labor market and so forth. Recessions increase the reserve army of labor and reduce the power of labor *vis-à-vis* capital, but recoveries only slowly draw down the reserve army. Therefore, the intensity of exploitation is expected to be procyclical. Figure four gives a scatter plot of the rate of GDP

¹⁵ Unit root tests for the variables are presented in table two.

growth and our measure of intensity of exploitation. The scatter plot has a positively sloped regression line, confirming the intuition that the measure of intensity is procyclical.

[Figure 4]

The deviation of the real wage from the value of labor-power, z_{2t} , was computed as the deviation of the real wage rate series – the nominal hourly wage in Duménil and Lévy (2009) deflated by the consumer price index – from its trend. The trend of the real wage rate has again been computed using the Hodrick-Prescott filter with a smoothing parameter of 6.25. Thus, the procedure is identical to that described above for constructing the measure of the intensity of exploitation. The intuition behind the construction of this variable rests on the idea that, in the long run, the value of labor-power is equal to the real wage rate, or, to put it differently, the trend in the real wage rate series is the value of labor-power. Hence, the deviation of the real wage from its trend is the deviation of the real wage from the value of labor-power. Just like the intensity of exploitation, the deviation of the real wage from the value of labor power can be expected to be procyclical. Figure five gives a scatter plot of the rate of GDP growth and the deviation of the real wage from the value of labour power. The scatter plot has a positively sloped regression line as expected. This confirms the intuition that the deviation of the real wage from the value of labour power is procyclical.

[Figure 5]

Overpopulation in the economy, z_{3t} , is measured by the civilian unemployment rate. Though the pool of unemployed workers is only one component of the reserve army of labor, fluctuations of the unemployment rate seems to be a good proxy for the relative overpopulation in the economy, *i.e.*, relative to the needs of capital accumulation. Thus, when the unemployment rate falls, the pool of labor that capital can draw on also falls *ceteris paribus*.

Figure six plots the civilian unemployment rate and the profit rate together to visually inspect the operation of this trending cointendency. It is interesting to note, from figure six, that this cointendency seems to operate in a contrary fashion to what one would expect: rising relative surplus population increasing the rate of profit by increasing the rate of surplus value. Figure six, in fact, displays the opposite. There is a rising trend of the civilian unemployment rate from 1947 to 1957 together with a declining profit rate; a declining unemployment rate over the next decade and a rising trend in the profit rate; a rising trend in the unemployment rate from the late 1960s to the early 1980s being juxtaposed to a marked decline in profitability. It seems that this cointendency, the relative surplus population, was always overwhelmed by the other trending cointendency, the relative price of capital.

[Figure 6]

The relative price of constant capital, z_{4t} , is computed as the ratio of an implicit price deflator for the capital stock and the consumer price index. The implicit price deflator for the net stock of private fixed assets is computed in two steps using the formulae in the NIPA Guide (NIPA, 2005). In the first step, the chained dollar value of the stock of fixed assets is computed with data

from the BEA's Fixed Assets Table 6.2 with a base year of 2005; for this computation, the current dollar value of the fixed asset stock is taken from Fixed Assets Table 6.1. In the second step, the implicit price deflator is computed, again, per the NIPA Guide (NIPA, 2005).

Inclusion of the measure of the relative price of constant capital follows the discussion in Michl (1988). This variable attempts to capture the cheapening of the elements of constant capital relative to the elements of variable capital, both due to technological progress and imports. If the rate of technological progress in the capital goods sector is faster than the rate of technical progress in the overall economy, that would reduce the price of capital goods faster than the price of other goods. This might act as a countervailing force to the tendency for the rate of profit to fall (Michl, 1988). Note, however, that our denominator differs from that of Michl (1988). The appropriate logic for capitalists does not consist of a comparison between the price of capital and the price of all final goods and services. Rather, the appropriate comparison is between the price of fixed capital and wage goods (which is relevant for the price component of variable capital); hence we use the CPI instead of the GDP deflator to compute the relative price of the capital stock. Since the value composition of capital, c/v , is formed by the ratio of the value of constant to the value of variable capital, changes in the relative price of capital to consumer goods, which captures the relative rates of technical change in the two sectors, will be a relevant counteracting influence *ceteris paribus*.

Figure seven plots our measure of the relative price of capital and the rate of profit in the same chart, once again, to visually inspect the operation of this countertendency. Our previous discussion suggests that the evolution of the relative price of capital should impart an opposite

direction to the rate of profit: when the relative price of capital falls, the rate of profit should get a boost and increase. Figure seven shows that over the whole postwar period, the relative price of capital moves in the expected manner. From 1947 to the late 1970s, the relative price of capital increases; that is also the period of declining profitability; interestingly, the dip in the relative price of capital in the early 1960s is also a period of rising profits. On the other hand, the relative price of capital has seen a pronounced fall between the early 1980s and the late 1990s, which is also a period of rising profits. Hence, the relative price of capital seems to be a powerful countertendency; it operates more or less as Marx had suggested, though perhaps with a variable time lag.

[Figure 7]

5.3. Econometric Methodology

Even though the parameters in (3) can be estimated by OLS, valid statistical inference will require us to pay attention to some econometric issues. These issues arise from the fact that the dependent variable (r_t) and two of the regressors (z_{3t}, z_{4t}) in (3) are unit root nonstationary (see table two). Hence, valid statistical inference on β (the coefficient on the time trend) will depend crucially on whether the error, u_t , in the regression (3) is stationary or nonstationary.

[Table 3]

If the error term is stationary, then (3) will be a cointegrating regression and standard inference procedures (t-tests and F-tests) will work; if the error term is nonstationary, then (3) will be a

spurious regression and standard inference procedures will break down.¹⁶ One way to deal with spurious regressions is to augment the original regression by including lags of the dependent variable and the nonstationary independent variables as regressors; since now, by construction, we can come up with a non-zero cointegrating vector, this augmented regression is a cointegrating regression and standard inference procedures are once again valid (Hamilton, 1994, pp. 561-62).¹⁷

Since the error term is not observable, we will be testing for the presence of unit roots in the residuals from the estimated version of (3) to draw inferences about the nonstationarity of the (unobservable) error term. It is well known that unit root tests have low power. Hence, we will report results from the estimation of both specifications: (a) the *original regression* in (3), and (b) the following *augmented regression* (which includes lags of the dependent variable and lags of the nonstationary independent variables):

$$\ln(r_t) = \alpha + \beta t + \gamma_1 z_{1t} + \gamma_2 z_{2t} + \gamma_3 z_{3t} + \gamma_4 z_{4t} + \delta_1 \ln(r_{t-1}) + \delta_2 z_{3t-1} + \delta_3 z_{4t-1} + u_t. \quad (6)$$

5.4. Results

Table two presents results of standard unit root tests on the variables in our empirical model (3) and (6). The results suggest that the rate of profit, the measure of overpopulation and the relative price of capital stock are unit root nonstationary; the intensity of exploitation and the deviation of the real wage from the value of labor power, on the other hand, are stationary. This suggests that

¹⁶ For an introduction to spurious regressions and cointegration analysis see, for instance, Hamilton (1994).

¹⁷ Faced with nonstationarity, often researchers adopt the route of “differencing” the data; we do not follow this route because differencing throws away important information about low-frequency components of the data. We would like to thank Duncan Foley for directing our attention to this possible pitfall.

we need to test for the stationarity of the error term in (3); if the errors are stationary we can use (3) and if they are unit root nonstationary we need to use (6) for valid statistical inference.

Table three presents estimation results for the regression models in (3) and (6) and unit root tests of the residuals from each model. The first thing we would like to point out is that the null hypothesis of unit root cannot be rejected at standard levels of statistical significance for the residuals from regression (3). This suggests that the original regression model in (3) might be a spurious regression model; hence, standard methods of inference (for instance the t-tests on the parameters) might not be very reliable.

This immediately suggests that the augmented regression model in (6) offers a better framework for testing the crucial hypothesis of the LTFRP, i.e., $H_0: \beta = 0$ against $H_1: \beta < 0$. Results of both the ADF and the Phillips-Perron tests on the residuals from (6) suggest that the null of unit root can be rejected: the PP test rejects the null at 10% and the ADF test at the 15% level of significance. Thus, the augmented regression is a cointegrating regression and standard methods of inference are valid. Note, moreover, that since we are in a cointegration framework we need not worry about endogeneity bias for asymptotic inference (Hayashi, 2000; pp. 651).

Turning to the estimated coefficients for (6) in the last column of table three, we note first and foremost that the coefficient on the time trend is negative and statistically significant.¹⁸ We interpret this as *evidence in favor the LTFRP*: when we control for the counteracting tendencies

¹⁸ Even though Hamilton (1994) does not discuss this issue in detail, we suspect that the coefficient on the time trend in specification (6) can have a nonstandard distribution. When we computed the critical values using Monte Carlo methods, the significance level of the negative time trend drops to about 11 percent, a little lower than what one would get using a Gaussian distribution. More detailed exploration of this issue of left for future research.

that Marx had explicitly mentioned and also take account of nonstationarity, we find statistical evidence in favor of Marx's hypothesis regarding the tendency of the general rate of profit to fall over time. The numerical estimate of -0.002 can be interpreted as suggesting that the general rate of profit fell every year by about 0.2 percent in the post-war period in the U.S.

All the estimated coefficients in the last column of table three have the expected signs other than the (contemporaneous) measure of overpopulation which shows up as negative but statistically not significantly different from zero. A lag of the measure of overpopulation has a statistically significant positive sign; hence, increase in the relative surplus population seems to have a lagged positive effect on the rate of profit. The estimate of the effect of the intensity of exploitation is positive: with higher intensity of exploitation, the rate of surplus value and thereby the rate of profit increases; the effect of the (positive) deviation of the wage from the value of labor power is negative, as expected: increase in the real wage above the value of labor power reduces the rate of surplus value and imparts a negative effect on the rate of profit. The effect of the relative price of capital stock on the rate of profit is numerically the largest and negative, once again as expected: when the relative price of capital stock falls, i.e., when there is what Marx termed the relative cheapening of the elements of constant capital, the rate of profit tends to go up.

6. Conclusion

Marx's claim in Volume III of Capital regarding the tendency for the general rate of profit to fall has spawned an enormous literature. While the theoretical strand of the literature has focused on understanding the possible causes of this tendency, this paper has focused on an econometric

analysis of Marx's hypothesis. A major lacuna of the existing literature has been the dearth of serious econometric inquiry to inform empirical analysis. As we noted earlier, a preponderance of studies utilize only exploratory techniques such as visual inspection of time series plots.

Starting with a systematic investigation of the statistical properties of the profit rate series, we arrive at the conclusion that the rate of profit displays unit root non-stationarity. Our initial inspection of the sample autocorrelation function suggests that the rate of profit is either a stationary AR process (with a root near unity) or is non-stationary. To “choose” the best model, we estimated an array of models, ranging from ARIMA(3,1,0) to ARIMA(0,1,0), and concluded that ARIMA(0,1,0) (*unit root without a drift*) provides the best fit for these data. Diagnostic testing does not lead us to reject this model.

Any time series with unit root nonstationarity will display considerable persistence. Such persistence, for unit root without drift, will emerge as "long waves" in the series. When such a series begins a decline, this fall continues for some time before a reversal of the declining trend. Likewise, when beginning its ascent, it continues to rise for a substantial number of periods. Following a tradition of economists that have studied long waves under capitalism, some scholars have speculated that long waves of aggregate economic activity might be related to long waves of the general rate of profit. A plot of the general rate of profit for the US economy since 1869 indeed displays long waves in its Lowess trend.

Using the nonstationarity of the profit rate series and explicitly accounting for the counter-tendencies that Marx had mentioned in Volume III of Capital, we build a novel econometric

model to test Marx's hypothesis, which specifies that the expected rate of profit is impacted by the intensity of exploitation, the relative cheapening of the elements of constant capital, the deviation of the wage rate from the value of labor power, the existence of relative overpopulation in the labor market, and a deterministic time trend. Most empirical studies have simply examined time series plots and fit a trend to these data. However, existence or nonexistence of a downward trend is not a valid test of Marx's hypothesis unless the counter-tendencies are appropriately controlled for.

While we can estimate the parameters of our model by ordinary least squares, we confront serious statistical difficulties related to the assumptions that ensure the optimality of the standard estimator. The usual methods of inference (e.g., involving the t-statistic) will not be valid if the error term is nonstationary. Since usual unit root tests suggest that the model in (3) has nonstationary errors (which makes the model a spurious regression model), we adopt a technique to transform it into a cointegrating regression by incorporating lags of the dependent and nonstationary independent variables. This augmented regression model makes standard statistical inference valid and allows us to test Marx's hypothesis regarding the LTFRP.

The key finding of this paper is that the deterministic trend is negative and statistically significant at standard levels of statistical significance. Indeed, the tendency of the rate of profit to fall is given a precise econometric meaning: the rate of profit declines at a rate of approximately 0.2 percent per annum after controlling for the counter-tendencies over the period 1948-2007. This finding draws attention to the existence of possible mechanisms, like the inexorable mechanization under capitalist production or the long-run labor-saving bias of

technological change, that drive the rate of profit to *conditionally* decline over time. When the counteracting tendencies are strong enough to nullify or even reverse this mechanism, the rate of profit might display an upward movement (as in the period 1982-2000). The relative strengths of these opposing forces will need careful investigation in each particular instance, and this will help to ascertain the concrete factors that influence the movement of the rate of profit. Marquetti et al. (2010) provides an excellent example of such an analysis for Brazil.

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Table 1: ARIMA Estimates

Model	b₁	b₂	b₃	s	LLK	AIC	BIC
ARIMA (3,1,0)	0.044	0.058	-0.101	0.012	170.72	-333.439	-325.267
ARIMA (2,1,0)	0.040	0.056	N/A	0.012	170.43	-334.866	-328.736
ARIMA (1,1,0)	0.042	N/A	N/A	0.012	170.35	-336.693	-332.607
ARIMA (0,1,0)	N/A	N/A	N/A	0.012	170.30	-338.596	-332.607

Notes: s^2 is the variance of the estimated residual, LLK is the log-likelihood evaluated at the estimated parameter values, AIC is the Akaike Information Criterion and BIC is the Bayesian (or Schwarz) Information Criterion.

Table 2: Unit Root Tests

Variable	ADF (t statistic)	Phillips-Perron (Z_ρ statistic)
Rate of profit	-0.480	-8.648
Intensity of Exploitation	-7.248***	-35.174***
Deviation of real wage from the value of labor power	-6.409***	-52.899***
Measure of overpopulation	-0.838	-15.555
Relative price of capital stock	-0.042	-3.982

Notes: The null hypotheses for the augmented Dickey-Fuller (ADF) and the Phillips-Perron tests are that the variable in question has a unit root. Refer to tables B.5 and B.6 in Hamilton (1994) for critical values. '****' means we reject the null hypothesis at the one percent level.

Table 3: Estimation Results

Dependent Variable:	Original	Augmented
Natural logarithm of the rate of profit	Regression	Regression
Time Trend	-0.004***	-0.002***
Intensity of Exploitation	0.049***	0.045***
Deviation of real wage from value of labor power	-0.019*	-0.019*
Relative overpopulation	-0.039***	-0.002
Relative price of capital stock	-0.943***	-1.160*
Measure of overpopulation, 1 Lag		0.018*
Relative price of capital stock, 1 Lag		0.447
Log rate of profit, 1 Lag		0.843***
Intercept	6.942***	3.465***
Adjusted coefficient of determination	0.736	
Unit Root Test of Residuals		
Augmented Dickey-Fuller Test (t-stat)	-2.483	-3.940
Phillips-Perron Test (Z_ρ statistic)	-14.995	-37.910 ^{##}

Notes: For the unit root tests of the residuals, critical values from tables B.8 and B.9 of Hamilton (1994) have been used and '##' means that we can reject the null of unit root at the 10% level. Significance codes for the estimated coefficients are as follows: '***' denotes 0, '**' denotes 0.001 and '*' denotes 0.01.

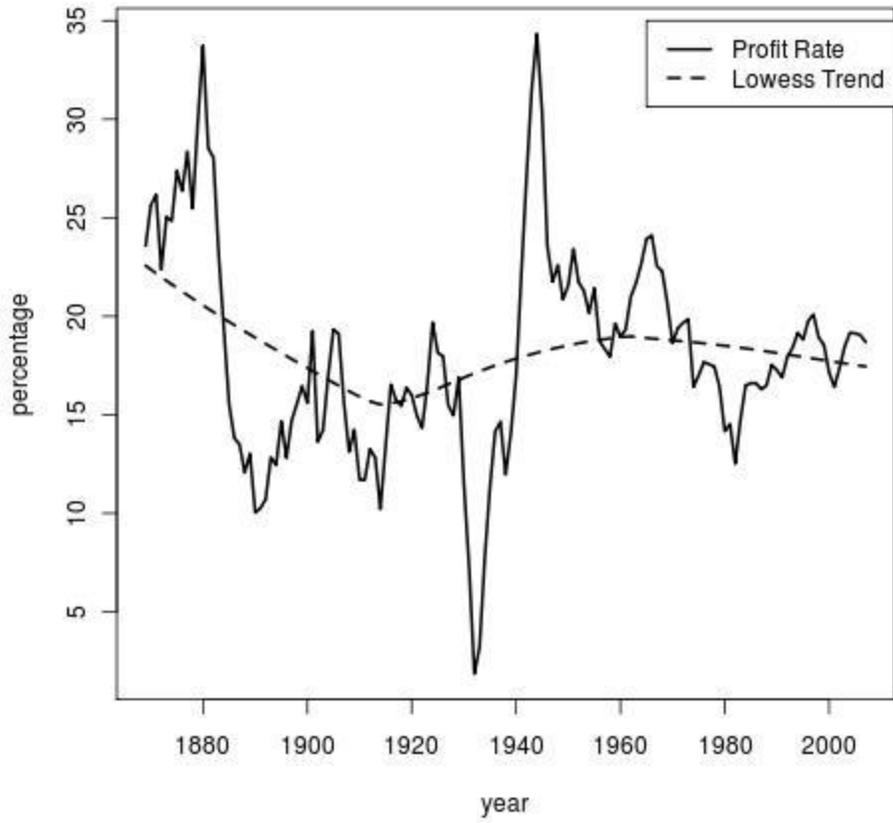


Figure 1: Long Waves in the U.S. Profit Rate, 1869-2007

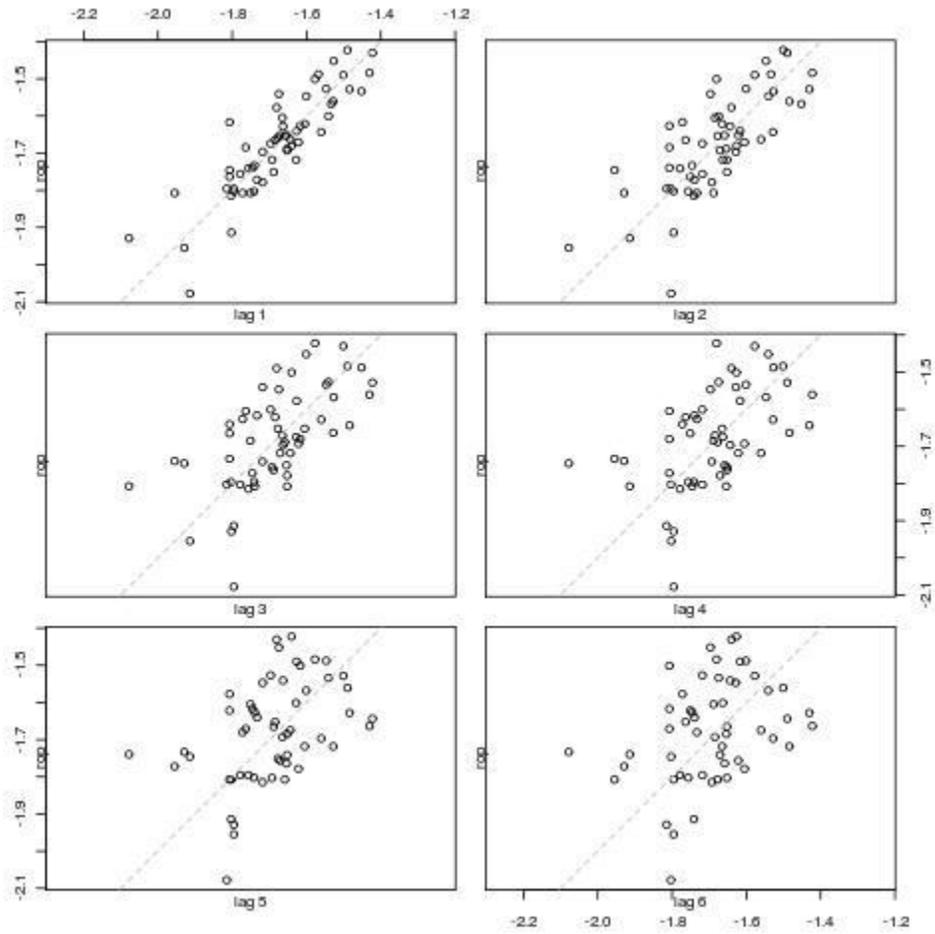


Figure 2: Lag Plots of the U.S Profit Rate, 1948-2007

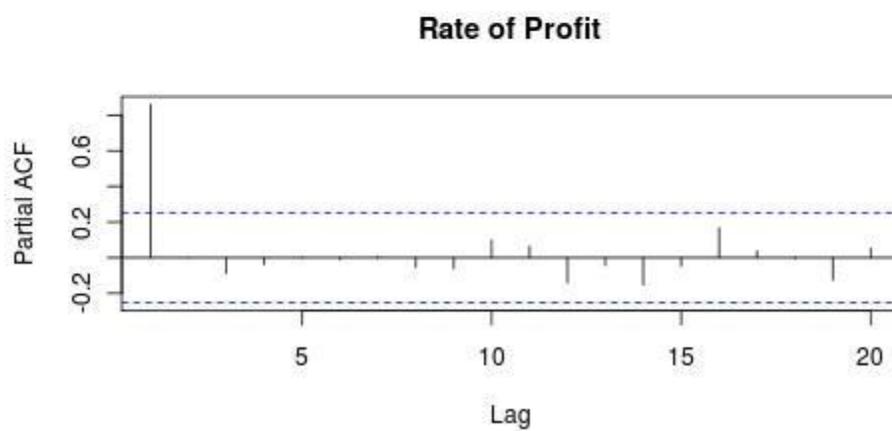
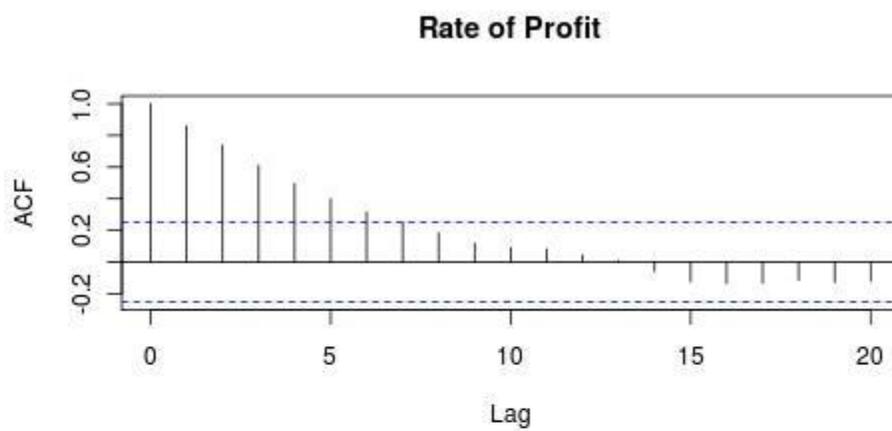


Figure 3: Sample ACF and PACF for the U.S. Rate of Profit, 1948-2009

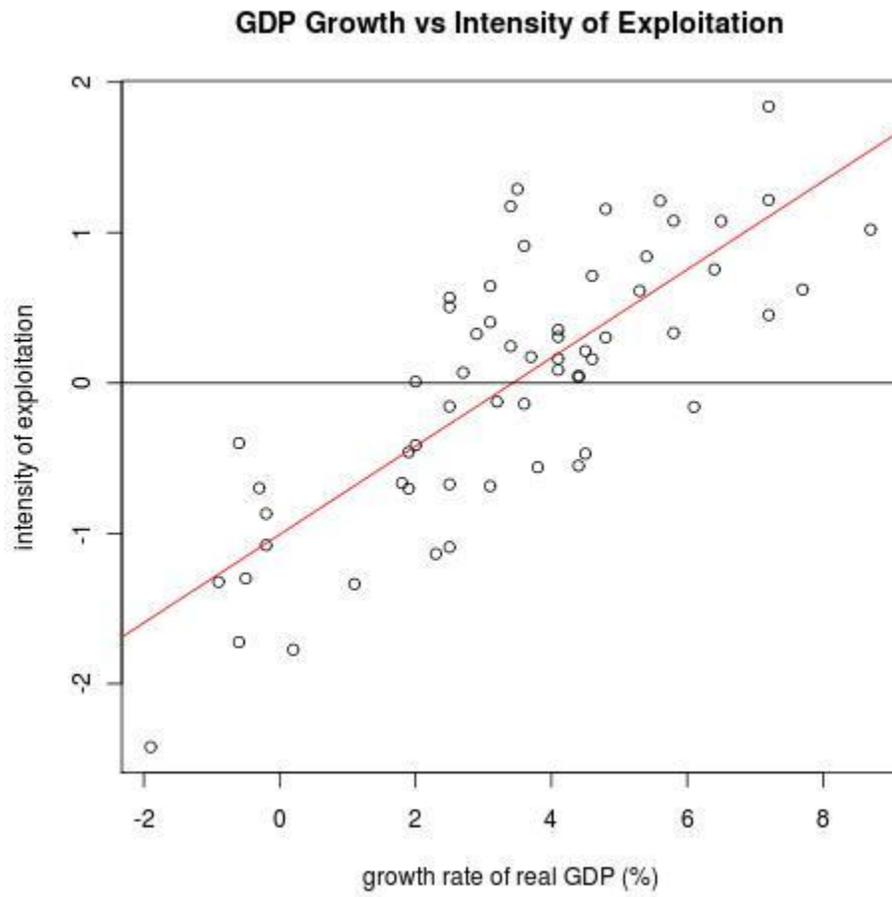


Figure 4: Scatterplot of Intensity of Exploitation and Output Growth

GDP Growth vs Deviation of Wage from Value of LP

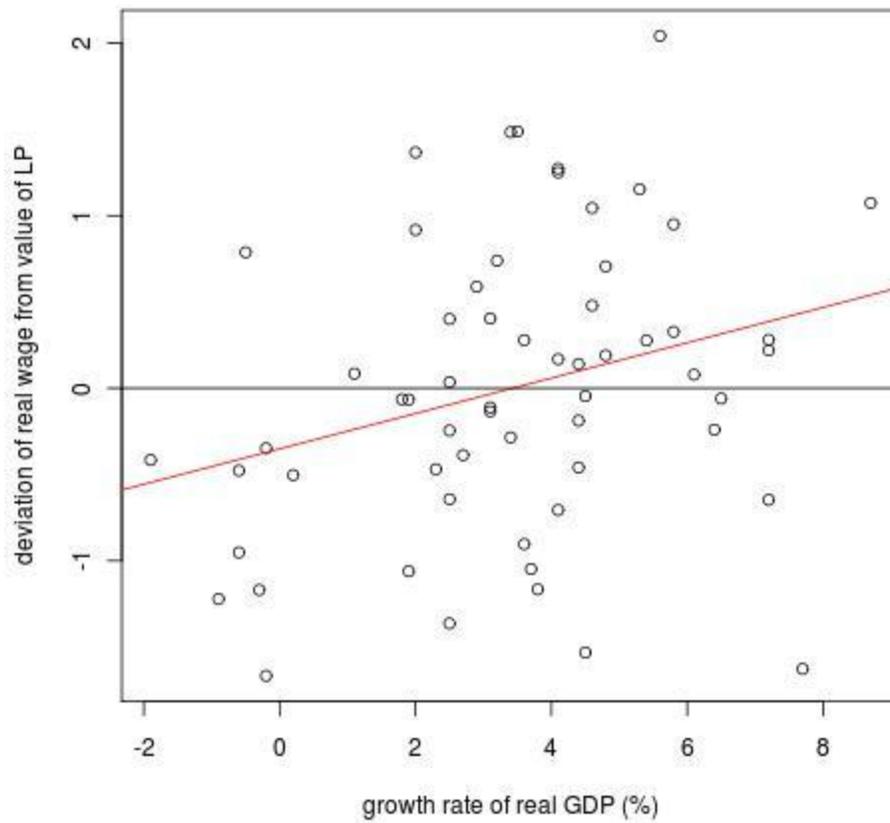


Figure 5: Scatterplot of Deviation of Real Wage from the Value of Labor Power and Output Growth

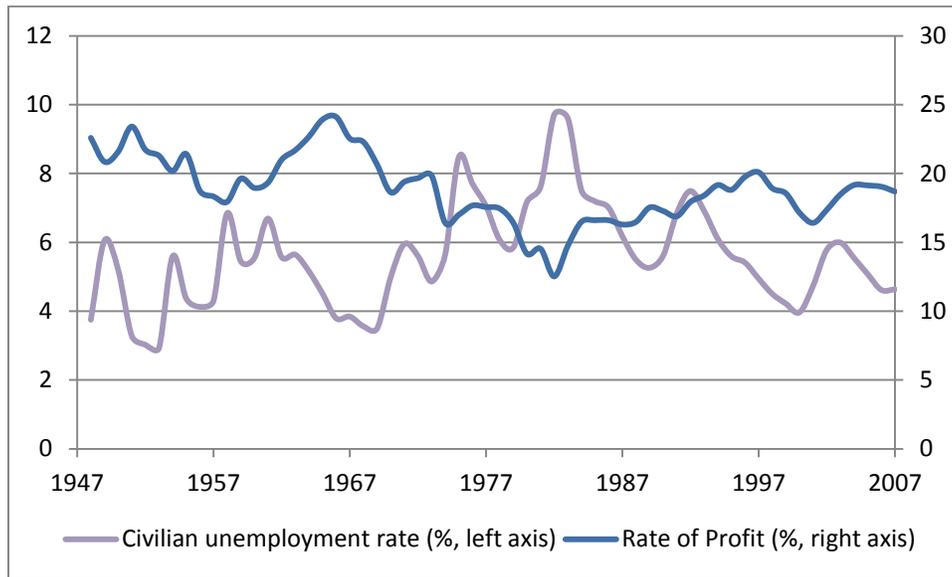


Figure 6: Relative Overpopulation and the Rate of Profit

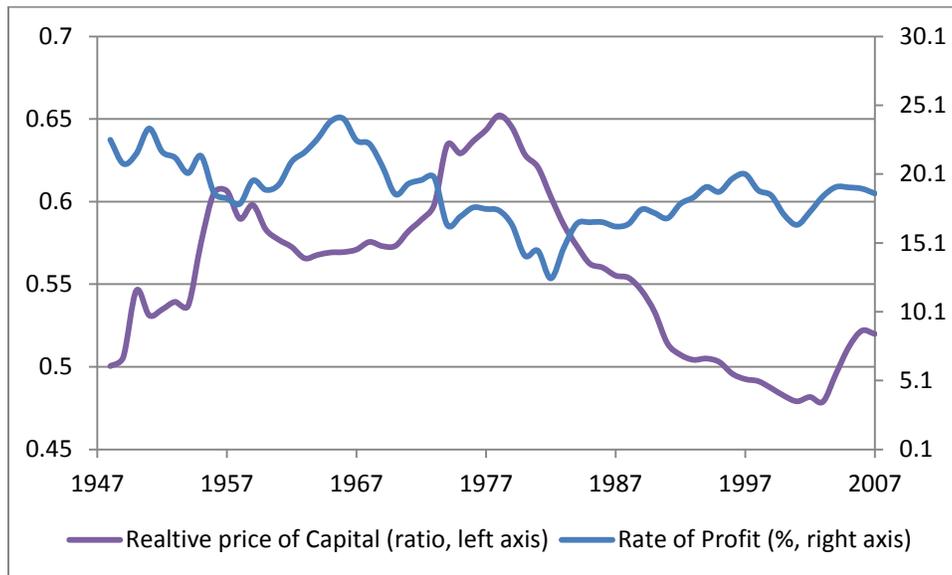


Figure 7: Relative Price of Capital and the Rate of Profit