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Technology, distribution, and long-run profit rate dynamics in the U.S. manufacturing sector, 1948-2011: evidence from a Vector Error Correction Model (VECM)

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Abstract: The examination of the determining factors of long-run profitability in the manufacturing sector has been largely neglected in the literature. Existing studies either overlook the internal profit dynamics of the sector for the sake of international developments or do not go beyond the application of descriptive statistics. Starting from the theoretical concepts of Marx-biased technical change and the tendential fall in the rate of profit, we intend to fill this gap with the use of multivariate cointegration analysis. A Vector Error Correction Model using a time-series dataset that covers the entire postwar era is applied to test the long-run relationship between the rate of profit and a set of variables. The analysis is extended to capital-intensive and labour-intensive industries within manufacturing. We find one true long-run relationship between the set of variables in all models. Capital intensity is found to have a negative impact on the profit rate in all models tested, providing evidence for Marx-biased technical change. The effect of real wages is also negative in the models where a statistically significant contribution is established. Labour productivity has the largest positive effect in all models and is promoted as the decisive counteracting force to the negative burdens on the rate of profit. A secular declining trend in the rate of profit cannot be confirmed.

Key words: U.S. manufacturing sector, technical change, capital accumulation, real wages, falling rate of profit, Marx, cointegration, VECM

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Table of Contents

List of Tables

List of Abbreviations

BEA – Bureau of Economic Analysis
BLS – Bureau of Labor Statistics
GDP – Gross Domestic Product
LTRPF – Law of the Tendency of the Rate of Profit to Fall
OCC – Organic Composition of Capital
OECD – Organization of Economic Cooperation and Development
NBER – National Bureau of Economic Research
NIPA – National Income and Product Accounts
NVA – Net Value Added
TSSI – Temporal Single-System Interpretation
VAR – Vector Autoregressive Model
VECM – Vector Error Correction Model

Preface and acknowledgements

This paper draws freely and builds upon previous work of mine that has been submitted during the last two years as course work and especially from my last year's master thesis, Kalogerakos (2013). The main area of influence is the theoretical framework where I have extended the concepts that I used last year. Some parts of the econometric methodology and the reasoning behind it are similar with a methodological paper that I wrote in spring 2014 for the course "EKHM44 Advanced Time Series Analysis" and is entitled "Human capital and economic growth in Sweden: time series evidence, 1890-2000".

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1. Introduction

What is it that defines the long-run evolution and dynamism of the profit rate in the manufacturing sector? Is it technological advancements as manifested by increasing capital intensity or rather the distributional aspect of the wage-profit relationship? Is the long-run impact of capital intensity on the profit rate positive or negative? What is the role of labour productivity and unemployment? These questions have received very little attention in scholarly publications. U.S. manufacturing is usually examined in an international perspective, which downgrades the internal developments of accumulation and profitability within the sector if it does not entirely neglect them. In this paper, we apply multivariate cointegration analysis and a Vector Error Correction Model (VECM) to a detailed dataset covering the entire postwar period to this day. Apart from the investigation of the entire manufacturing sector, we disaggregate the level of analysis further, in order to account for any distinct patterns in capital-intensive and labour-intensive manufacturing. Contrary to common belief in the field, we find that capital intensity exerts a negative influence on the profit rate in the long run, which can be considered as evidence of Marx-biased technical change. Its effect is found to be larger in labour-intensive manufacturing, in contrast to our theoretical expectations. Labour productivity is found to be the most significant positive influence on the profit rate, able to counterbalance the negative effect of rising capital intensity and real wage growth.

Manufacturing was for a long period the cornerstone of the U.S. economy and a well performing manufacturing sector was considered essential for a thriving economy. The Great Recession has intensified a dominant declining trend in the manufacturing sector in terms of employment, which was already on a course of capital deepening/labour substituting technical bias. Domestic investment in manufacturing as well as manufacturing as a productive sector have declined greatly over the last thirty years and many people have lost their jobs in this process. The once prevailing American industry is barely ahead of China as the world's top manufacturer, in terms of total value added (Nathan, 2012; World Bank, 2013). Despite these developments, there is a shortage of papers that focus on the profit rate dynamics of the sector.

The formation of new capital is an essential aspect of free market capitalism, especially when we are investigating a relatively capital-intensive sector as manufacturing. Investments are driven by the urge for higher profits and increased capital accumulation. Hence, profitability is a key determinant in the long-term accumulation process and is very important when examining the dynamic development of the sector in relation to technology and distribution. The core of our theoretical analysis is based on the concepts of Marx-biased technical change and the tendency of the rate of profit to fall, which are thoroughly explained in the next section. From this standpoint, we attempt to develop some statistically testable hypotheses and a comprehensive model that accounts both for the effect of capital deepening and for the counteracting forces that work against it.

Determining the driving forces behind profit rate fluctuations in the manufacturing sector in the postwar era is an intriguing task since both widespread technological advancements and changes in the power relations between labour and capital have taken place during this period. What is more, the analysis on a higher level of disaggregation will enable us to formulate more sound conclusions on the interrelation between technology and distribution and the way they affect profitability when the nature of production promotes the use of either dead labour (capital) or living labour (workers). The goal of this research project is to investigate the long-run impact of the proximate determinants of the profit rate in the U.S. manufacturing sector. Our main concern will be to clarify whether capital intensity is beneficial or detrimental for the long-run profitability of the manufacturing sector. Apart from that, we want to determine the long-run effect of real wages, labour productivity, and unemployment on the profit rate and examine whether a secular declining trend in the rate of profit can be verified in any model.

The remainder of this paper is structured as follows. The next section presents the main theoretical concepts on which we base our analysis and the testable hypotheses we formulate from them. Section 3 features a review of similar research projects and the presentation of their results. Section 4 contains the main data sources, known methodological issues, and an outline of the empirical strategy and time-series econometrics to be used in the analysis. Section 5 comprises of the estimated results and the last section offers our conclusion.

2. Theoretical framework and hypotheses

2.1. Basic theoretical concepts

This research project adopts its main theoretical tools and concepts from the Marxian literature on profit rate dynamics and their relation to technical change and distribution. The two basic theoretical constructions that will be used in our analysis are, first, what is usually referred to as Marx-biased technical change, and second, Marx's "Law of the Tendency of the Rate of Profit to Fall" (LTRPF).

The profit rate is one of the core variables in Marxian economics. It plays a decisive role in the development of capital accumulation and investment policies, which in turn, largely define the successful reproduction and growth of the economy.[1] Hence, the general environment of profitability and accumulation must be in the kernel of a structural analysis of the development of the U.S. manufacturing sector. The profit rate is generally defined as the ratio of profit flows for a certain period to the advanced capital that was used during that specific period in the creation and realization of this profit. The *profit rate (ρ)* can be expressed mathematically and in accordance with Marx in the following manner:

$$\rho = \frac{s}{C} = \frac{s}{c+v} = \frac{s/v}{c/v+1}, \qquad (1)$$

where *s* is the *surplus value (s)*, i.e. the total amount of profit produced in a period, which is divided by the total amount of capital invested in that period *(C)*, which in turn is the sum of *constant capital (c)* (i.e. plants, machinery, raw materials etc.) and *variable capital (v)* (employee compensation). If we further divide the first equation by *v*, we derive at the final form of equation (1). The *s/v* fraction is the *rate of surplus value* (or

[1] *"It is the rate of profit that is the driving force in capitalist production, and nothing is produced save what can be produced at a profit. Hence the concern of the English economists over the decline in the profit rate. […] No capitalist voluntarily applies a new method of production, no matter how much more productive it may be or how much it might raise the rate of surplus-value, if it reduces the rate of profit."* (Marx, 1991, pp. 368, 373).

rate of exploitation) and the *c/v* fraction is the *organic composition of capital (OCC)* in value terms.

The introduction of labour-saving/capital-using technological innovations captures the concept of Marx-biased technical change fully. In this argumentation, Marx starts from the micro-level, i.e. the specific behavior of the individual capitalist or firm to maximize its profit through labour substitution, in order to deduce the more general macroeconomic phenomenon of the tendency of the profit rate to fall (Roemer, 1979). According to him (1991, Part III, Chapter 13), during the process of capitalist development and increasing competition, there is an endogenous drive for the individual capitalist to introduce new technology in order to raise the labour productivity and thus the rate of surplus value. Since technological innovation implies the use of more means of production compared to living labor (the *technical composition of capital* in Marxian terms or else capital intensity), then ceteris paribus, a rise in the OCC, which is the denominator in equation (1) would cause a decline in the rate of profit. The same would happen in any case of an increase in the OCC *(c/v)* which is greater than the rise in the rate of surplus value *(s/v)*. For the profit rate to fall, under the assumption of a constant rate of exploitation (constant wage share) and increasing labour productivity, the real wage must necessarily rise, as Nobuo Okishio (1961) has shown. This means that the position of workers is improved in absolute terms, as their real wage increases, but their relative position in the economy vis-à-vis capitalists remains the same.

Despite the purely technological aspect of labour-saving/capital-using technical change that is associated with innovation, a rise in the OCC may also be promoted by companies, if they want to constrain real wage growth. In periods of high profitability, there is also high capital accumulation and thus increased investment. This subsequently leads to a rise in the demand for employment, which at some point will push real wages upwards (especially when close to full employment) and create a negative pressure on the rate of profit. According to Marx, this problem is resolved through the mechanism of recurrent crises that lead to declining production, capital devaluation, and hence a recovery in unemployment that pushes wage growth or real wages down again (Duménil & Lévy, 2003).

Despite the fact that the LTRPF holds a central position in Marx's analysis of the capitalist economy, he acknowledged that there are specific assumptions that have to be met for this "law" to be valid. He also wrote thoroughly about the *"counteracting forces"* that work against the fall in the rate of profit and that is why he only refers to a tendential instead of an absolute fall (Marx, 1991, Part III, Chapter 14). Hence, we do not expect to come across a secular decline in the rate profit but only a negative tendency, especially in the periods when the capacity for technological innovation and diffusion of technical change has been exhausted. Thus, in conclusion, we want to call attention to the fact that this "law" must only be tested using the scientific method of abstraction in the quest of discovering the endogenous dynamic forces that would affect the profit rate if all other independent variables remained constant (Milios, Dimoulis, & Economakis, 2002, pp. 194-196).

The LTRPF has been both praised and criticized for its theoretical and empirical strengths and weaknesses by a variety of scholars within academia. Nobuo Okishio, a Japanese economist that specialized in Marxian economics, has written the most known critique of the LTRPF to this day in 1961. Assuming that real wages remain constant and that labour-saving/capital-using technical change is only introduced in production if it is cost efficient (reduces the cost per unit of output), he developed an economic model to prove that the rate of profit would in every case rise and under no circumstances fall (Okishio, 1961, 1993). Mikhail von Tugan-Baranowsky, another Marxist theoretician, had developed a similar model sixty years earlier and had found similar results that led him to also criticize the validity of the law (Milios et al., 2002, pp. 150-156; Tugan-Baranowsky, 2000). Okishio's contribution in the debate for the validity of the LTRPF led to a new round of theoretical and empirical investigations and produced a new wave of critics and supporters (Roemer, 1981; A. Shaikh, 1978a, 1978b). Recently, a group of Marxist economists that accept the so-called "Temporal Single-System Interpretation (TSSI)" of the Value Theory asserted that the LTRPF is valid and internally consistent under different assumptions, thus reigniting the theoretical dispute in the field. Their argument is founded on the assumption the constant fixed capital stock (net or gross) of any given firm in the economy must be calculated according to its historical-cost (HC) value (the value at the time of purchase) and not by its current-cost (CC) valuation. They claim that is because fixed capital is not devalued by future technological advances and increases in productivity that cheapen it or make it impossible to realize all the value that is embodied in it before its replacement (i.e. there is no moral depreciation).[2] To read further on the arguments of the advocates of the TSSI approach see Kliman (1997, 2007); Kliman and Freeman (2000a, 2000b); and Kliman and McGlone (1999). For the arguments of the other side of the controversy, the defenders of the "Okishio theorem", see Foley (2000); Laibman (1999, 2000a, 2000b).

At this point, we need to emphasize that the nature of this paper is not theoretical but rather empirical. We will not concern ourselves with proving or disproving the LTRPF, neither theoretically nor mathematically with the use of advanced algebra. We start from the concept of the LTRPF in order to examine the evolution of the profit rate in the U.S. manufacturing sector. For this reason, we will employ a more comprehensive empirical model that does not abide to the constrictions of theoretical modeling in order to evaluate the contribution of the proximate determinants of the profit rate in a more efficient manner. In our view, the validity of both the LTRPF and the "Okishio theorem" can be mathematically proven on the ground of different assumptions. The essence of the debate nevertheless, lies in how representative and scientifically accurate of the "real-world" conditions of capitalist development these different assumptions are. This discussion is however beyond the scope of the present research project. We certainly do not support a "fundamentalist", ahistorical, and non-dialectical interpretation of the LTRPF, which maintains that this law is inherent in capitalism, and we believe that such approaches do not help to extend the progression, credibility, and influence of Marxian economics in any valuable way. However, we are in total agreement with the words of Duncan Foley, who is among the prominent Marxian critics of the LTRPF:

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[2] Marx develops the concept of moral depreciation in the first Volume of *Capital*: *"If, as a result of a new invention, machinery of a particular kind can be produced with a lessened expenditure of labour, the old machinery undergoes a certain amount of depreciation, and therefore transfers proportionately less value to the product. […] But in addition to the material wear and tear, a machine also undergoes what we might call a moral depreciation. It loses exchange-value, either because machines of the same sort are being produced more cheaply than it was, or because better machines are entering into competition with it"* (Marx, 1990, pp. 318, 528).

> *"The power and usefulness of Marx's analysis of exploitation as the central social relation of capitalist society does not stand or fall on technical details of matrix algebra or difference equations. The notion that technical gaps in Marx's discussion of the transformation problem undermine his theory of exploitation is a line of argument largely advanced by Ricardian and marginalist critics of Marx whose motivation is to discredit rather than to clarify its contribution" (1999, p. 233).*

2.2. Counteracting forces

In order to construct a comprehensive model of profit rate dynamics and their determinants, we also have to account for the counteracting forces that are present at any specific historical conjecture. Those counterforces are associated with a rise in the nominator of equation (1), i.e. a rise in the rate of surplus value. Marx identified some factors that could lead to an increase in the rate of exploitation. First, the length of the working day, which can at least for most part of the 20th century be dismissed as a reason because generally the duration of the working day tended to drop because of labour unions' increased bargaining power. Nevertheless, technical innovations may increase the intensity of work as for example in the case of the conveyer belt, the assembly line, and the wider factory system organization that is associated with Fordism and was vastly implemented in manufacturing during the first postwar decades in the western world (Duménil & Lévy, 1999).

The other factors are associated with the level of technical development and the interrelation between labour productivity and real wage and the distributional aspect of the profit-wage share in total output. Real wages could remain stagnant or even drop with increasing productivity, which would lead to higher absolute surplus value. Another possibility is the cheapening of wages through the introduction of better technology (and thus higher productivity) in the sectors that produce wage goods, which would lead to a decrease in the consumer price index (CPI). Alternatively, nominal wages could increase at a pace lower than that of the CPI, which means that real wages would decline. However, we are also interested in the profit-wage share outcome because there is the possibility that real wages increase and at the same time, the wage share drops, because of relatively higher increases in labor productivity. These developments go beyond the sphere of technical or "economist" progression in a sector and are associated with class structure, class struggle, and the balance between the powers of labour and capital in a specific historic conjuncture. Hence, the outcome of these processes cannot be determined merely by the effect of technical change. Most papers that study the effect of labour-saving/capital-using technical change on profitability usually assume constant real wages or a constant wage share in total income, which is empirically not valid in the long run.

Another factor that needs to be taken into consideration regarding the dynamism of change in real wages and the wage share is unemployment. In the medium- or short-term perspective, when the economy is in the expansionary phase, unemployment tends to zero, the bargaining power of the working class rises and usually so does the wage share as well, hence putting pressure on the profit rate (Mandel, 1995). In periods of recession or structural crisis, unemployment increases rapidly and cancels this tendency thus restoring the rate of profit to its normal or higher than normal levels (Boddy & Crotty, 1975). An increased unemployment rate in a specific sector due to labour-saving technical change will most probably diminish the bargaining power of workers against their employers and make it harder for the former to push for real wage increases or maintain the wage share in its previous state (Roemer, 1978). However, unemployment generally tends to be quite high in periods of crisis and stagnation, and before the profit rate rises again. Hence, this double "nature" of unemployment, both as an epiphenomenon of the crisis and as a means of overcoming it, makes it hard to formulate explicit hypotheses on its influence on the profit rate.

Moreover, we must stress the difference between the technical and the organic composition of capital. A rise in the first (increased capital intensity) does not necessarily imply a rise in the second, as Marx himself had also pointed out (Marx, 1991, pp. 243-247). Even in the case of an increase in capital intensity, the value composition of capital may decline if advancements in technology lead to a higher devaluation in means of production than in wage goods. There are also economic theorists who have argued that every technology that is introduced in production is not necessarily progressive or costreducing, because it may be promoted in order to better control the workers and to establish the dominance of capital over labour (Roemer, 1978). A new technology that displaces labour in favour of machinery or enables the use of unskilled workers, thus creating what Marx termed the "industrial reserve army of labour", puts pressure on the employed wage earners and shifts the balance of power to the benefit of capitalists (Marx, 1990, pp. 781-794). In an extreme scenario, capitalists could implement technical change that is cost-increasing in the short run, but enables them to suppress real wages and the wage share in the medium- or long-term future.

Finally, the situation may arise, where, during a period of highly innovative activity and rapid technological progression that cannot be predicted, a new technology that was recently introduced becomes quickly obsolete and is replaced by another, which is more efficient and is expected to yield a higher rate of return. In this way, the investment and the value that was embodied in the means of production that are replaced for the sake of new, more efficient ones, never manages to materialize within the short period of use (Persky & Alberro, 1978). Thus, although a company may expect a higher rate of return, the actual rate of profit falls, at least in the short-run, because the high cost of investment in fixed capital cannot yield the expected profits within only a few economic periods. However, in the modern institutional environment for innovation that is dominated by mass scale R&D expenditures stemming mainly from huge corporations, the rate of technical change and the speed of innovation can be more easily predicted or even controlled by the leading innovators in an industry (Roemer, 1979). Despite of this, we have to keep in mind that large scale innovations that manage to shift the entire spectrum of economic activity (what Perez (2010) has labeled as the "techno-economic paradigm") into new growth paths seldom occur in economic history. It has been proven by the three industrial revolutions so far, that these innovations, which have also been branded as General Purpose Technologies (GPTs), share the characteristic of significantly boosting the productivity of both labour and capital at the same time (Duménil & Lévy, 2003).

2.3. Hypotheses

Based on the theoretical framework that we have presented so far we formulate the following hypotheses that we will attempt to test statistically with our econometric model:

- There will be at least one true long-run relationship between the profit rate, capital intensity, real wage, labour productivity, and the unemployment rate, in each of the sectors under examination. This will indicate that all, or a subset, of the variables are causally related.
- The expected long-run effect of the abovementioned variables on the profit rate is expected to be:
    - Positive for labour productivity in all manufacturing divisions. We expect labour productivity to have the most significant impact on the profit rate, since it is the factor that can cancel any negative tendency and will ultimately determine the outcome of the "battle" between the LTRPF and the counteracting forces.
    - Negative for capital intensity and the average real wage. Based on the nature of manufacturing, we expect the effect from capital intensity to be more significant in capital-intensive manufacturing and the effect of real wages to be more important in labour-intensive manufacturing.
    - If unemployment is a good proxy for wage manipulation and suppression, we expect it to have a positive effect on long-run profitability. If it merely picks up the effect of stagnation and crisis itself, its contribution will be negative. We expect its effect to be higher in labour-intensive manufacturing since workers in these industries are usually unskilled, easier to replace, and more vulnerable to pressure by international competition.
- If a statistically significant trend term can be observed, we expect it to be negative. If the trend term indicates that the rate of profit decreases autonomously by more than 1% per year, we will consider it evidence in favour of a secular declining trend for the period under scrutiny.

3. Previous research

Similar previous research on the topic that we are going to examine is not extensive with regard to the manufacturing sector and usually concerns more general approaches that focus on the entire economy of a country or a set of economies. The methodology that is followed in most of these papers is also diverging from our approach, since most of the times scholars use either descriptive statistics or some sort of decomposition method. Nevertheless, the essence of their research questions remains close to ours and this is the criterion with which we have chosen the papers that comprise the literature review. A more extensive literature review that goes further back in time and examines wider theoretical, methodological, and empirical approaches can be found in A. M. Shaikh and Tonak (1997) and Vaona (2011).

Robert Brenner (1998), who is one of the leading theorists of the "Monthly Review School", was one of the first to point to the manufacturing sector in order to explain declining profitability in the U.S. economy. According to him it was the big decline in the profit rate of manufacturing industries, which was above the equilibrium level in the first postwar decades, that led to a decline in the profit rate of the economy overall (Brenner, 1998). However, his analysis does not focus on the characteristics of technical change. He explained the eroding profitability in the U.S. economy as the outcome of overcapacity in the manufacturing sector. He claims that this overcapacity was produced because of the entrance of Newly Industrialized Countries – NICs (East Asian Tigers, China, and India) in the global manufacturing map, which led to the intensification of international competition and amplified the overcapacity problem in the advanced capitalist countries, thus not allowing for a restoration of profit rates.

Gérard Duménil and Dominique Lévy are two French economists who have written a wide series of papers concerning dynamic Marxian economic modeling in connection with historical tendencies of technological change and distribution. In one of their most cited works they find that profit rates for the core non-financial industries (durable and non-durable manufacturing being among them) in the U.S. economy tend to gravitate around a common value during the postwar period (Duménil & Lévy, 2002a). They assert however, that the profit rates for the highly capital-intensive industries do not gravitate with other industries and have generally been lower throughout the postwar period. They attribute this profit rate profile of the highly capital-intensive industries to the increased importance that capital productivity plays vis-à-vis labour productivity in these sectors. Their results show that is was capital productivity that played the most significant part in the decline of the profit rate in the period before the structural crisis of the 1970's, although profit shares were also declining in most industries (Duménil & Lévy, 2002b). Another factor that is promoted in their analysis and is also considered important for the fall of the profit share until 1980 is the larger decline in the growth rate of labour productivity compared to the decline of the real wage growth rate (Duménil & Lévy, 2002b). The authors attribute this to the fact that real wages adjust slower to a slowdown in productivity growth that arises when the development dynamics of a techno-economic paradigm saturate and the conditions of innovation deteriorate. Finally, their empirical results indicate that the post-1980's recovery in the profit rates of many industries is the outcome of both favorable technological progress (ICTs) that led to a boost in capital productivity and a redistribution of income in favour of profit that led to higher profit shares (Duménil & Lévy, 2002b). The theoretical and empirical analysis that is promoted by Beitel (2009) is almost identical with that of Duménil and Lévy. He too concludes that capital productivity was the main governing factor behind profit rate movements for the most part of the postwar period, namely from 1965 to 1996, although he also acknowledges the role of the increasing wage share during the period 1945-1965.

Basu and Vasudevan (2013) are examining profitability in the U.S. corporate business and non-financial corporate business sectors by employing a simple decomposition of the profit rate into the profit share and the output-capital ratio. The former captures changes in income distribution while the latter captures the influence of the dynamic development of productive forces and technological innovation in the variation of the profit rate. They find that capital productivity has been the main driver in the decline of the profit rate for the periods 1968-1982 and after the year 2000, having at present reached the lowest point in the entire postwar era. In the interval between these two periods, capital productivity shortly revived to some extent due to the Information and Communication Technologies' (ICTs) revolution, but this trend was reversed again after 2000. The increasing wage share is according to them also a factor that significantly contributed to the decline of the profit rate, especially after 1960 and up until 1982, after which this trend is reversed and follows a slight upward direction with business-cycle fluctuations (Basu & Vasudevan, 2013).

Another paper that deals with the profitability performance of the U.S. economy is that by Economakis, Anastasiadis, and Markaki (2010). They focus on the nonfinancial corporate business sector and investigate the period between 1929 and 2008. They find that fluctuations in the net fixed capital return, which they also use as the most accurate proxy of the profit rate, "*are mainly, but not exclusively, determined by the variations of real wages*" (Economakis et al., 2010). In their econometric model, average labour compensation has a bigger and more significant coefficient than capital intensity, with both of them exerting a negative influence on the profit rate, as is theoretically expected in the Marxian model. However, their results suggest that the most important factor is that of labour productivity which has the largest (positive) influence on *r*, and is according to the authors the variable that will ultimately define the direction of the profit rate. Their conclusion is that none of these three variables can be disregarded as unimportant and that scholars, who exclusively focus on, either the distributional (average wage) or the technological component (composition of capital) of profit rate variations, arrive at misleading results.

There is also a series of scholars who have looked into profit rate dynamics with regard to countries other than the U.S.A, although this task remains a big challenge even to this day due to the lack of relevant data in many cases. Andrea Vaona has produced a number of papers that examine many aspects of industrial and manufacturing rates of return with a focus on OECD countries using the STAN database. In one of his recent papers where he examines profit rate dynamics for Italy, Finland, and Denmark he finds some common patterns foe these three economies. First, his results indicate that in countries or periods when no significant redistribution of income in favour of profit occurs, the rate of profit tends to decline (Vaona, 2011). This pattern is observable in periods when the labour productivity growth largely outpaced the growth of real wages, thus leading to an increase in the profit/wages ratio. Second, when the labour productivity (growth) declines or stagnates, the profit/wages ratio declines because of a lag in the adjustment of real wages, thus leading to a decline in the profit rate (Vaona, 2011). This result is line with the one presented by Duménil and Lévy (2002b) for the U.S. economy. Furthermore, the author finds evidence that increased capital intensity leads to an upward tendency of the organic composition of capital, thus pointing to periods of Marx-biased technical change.

Memis (2007) looks into the structure of profit rate trends in Turkish manufacturing at a subsector level for the years 1970-2000. In order to better account for dynamic changes and policy implications she chooses to focus on two groups. More specifically, she creates a group out of labour intensive industries containing textiles, wearing apparel, and leather, and a group that contains capital-intensive industries such as fabricated metal products, machinery, and equipment. She uses the profit rate decomposition method proposed by Weisskopf (1992) to find that throughout the period of analysis, conflict-based factors (using real wage growth as a proxy for labour bargaining power) were more important than technological or other factors in determining the profit rate. She argues that distributional factors were more significant in increasing profits and compensating for profit losses in recession periods. Her findings indicate that this trend was more evident in labour intensive manufacturing, because of the employment structure and international competition. Wage earners in textile industries are most of the times unskilled, receive minimum pay, with high numbers of female employment, and thus are more easily susceptible to wage suppression because of the constant fear of unemployment (Memis, 2007).

Tsaliki and Tsoulfidis (1994) investigate long-term profitability trends in Greek manufacturing from 1955 to 1989 using the growth accounting framework proposed by Weisskopf (1979). They find that in the period under scrutiny there was an overall 7% decline in the rate of profit. Through their analysis, they conclude that this decline is mainly due to a delayed implementation of Keynesian economic policies in Greece, which led to an upsurge in real wages that was not met with a similar increase in labour productivity, hence leading to a "profit squeeze". In a more recent paper that follows a slightly different methodological and empirical approach, they find that profit rates in twenty industries of Greek manufacturing tend to gravitate around the overall economy's average profit rate (Tsoulfidis & Tsaliki, 2005). This tendential equalization of interindustry profit rates is according to the authors verifying the analysis of competition and technical change that is promoted by Marx, as we have presented it in section 2.

Izquierdo (2007) analyses profit rate dynamics for the entire Spanish economy regarding the period 1954-2001. He finds that the fall in the rate of profit until the early 1980’s is mainly due to technical change and the ongoing mechanization of the Spanish economy during the two postwar decades. He attributes this fall to the decline in the productivity of capital, but asserts that the cyclical fluctuations of the profit rate are primarily defined by the distributional factors, i.e. by the evolution of the real wage in relation with the evolution of unemployment.

Finally, one paper follows a distinct path and conducts a multinational comparative analysis of profit rate dynamics in the manufacturing sector of seven industrialized OECD economies. Gu (2012) studies the evolution of the profit rate in relation to the evolution of the exploitation rate to find that the latter is a significant factor in explaining the movements of the former in all seven countries, despite some distinct patterns among them, that he ascribes to differences in wider institutional and socioeconomic environments. His results however, also indicate that the growth of the organic composition of capital has been significantly detrimental for profit rate growth in the U.S., Spain, and Austria (Gu, 2012).

4. Data and methods

4.1. Main data sources and basic methodology

The sources of the data that are going to be used are the National Income and Product Accounts (NIPA) and the Fixed Asset (FA) tables, which are produced by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. Moreover, additional data from the Employment and Labor Force Statistics produced by the Bureau of Labour Statistics (BLS) of the U.S. Department of Labor will be utilized to account for shortcomings in the BEA data. All data that were in nominal values have been deflated with the GDP Deflator to reflect 2009 prices (base year). The main data that will be used in the analysis and in the construction of secondary variables are:[3]

- Net Value Added by Industry (in billions of 2009 dollars)
- Net Fixed Capital by Industry (in billions of 2009 dollars; yearend estimates; valued at current cost)[4]
- Full-Time Equivalent Employees by Industry (in thousands)
- Average Wage per Full-Time Equivalent Employee by Industry (in thousands of 2009 dollars)
- Unemployment rate (percent, seasonally adjusted, 16 years and over)

All the variables that are used in the empirical analysis are derived from these main groups of figures through simple transformations that are explained below.

Apart from the examination of the manufacturing sector as a whole, we will also test the same econometric model on two smaller industrial groups according to the capital intensity of each manufacturing industry or activity, namely capital-intensive and labour-intensive. These two groups do not add up to form the whole manufacturing sector, because their examination is intended to uncover any distinct patterns of profit rate dynamics, if there any that can be observed. Highly capital-intensive industries include

[3] For a detailed documentation of the data sources, see Appendix A – Data sources.
[4] For an empirical analysis on the differences in the BEA's methodology for computing historical-cost and current-cost measures of the net stock of capital in the US economy in reference with profit rates, see Basu (2013).

primary metals; food, beverage, and tobacco products; paper products; petroleum and coal products; and chemicals. Highly labour-intensive industries include wood and furniture products; textile, apparel, and leather products. We chose these industries based on the capital intensity that we calculated manually, by dividing the net fixed capital stock in a year with the corresponding number of full-time equivalent employees in a specific industrial sector.

In order to calculate the profit rate we will use the formula for calculating the net fixed capital return proposed by Duménil and Lévy (2004), which is the broadest measure of profitability. The abovementioned authors have in a series of papers described why this measure is the closest proxy to the Marxian equivalent of the profit rate and is considered more appropriate for such kind of statistical inquires (Duménil & Lévy, 1993, 2002b). As we mentioned above, the figures provided by the BEA for the net stock of private fixed assets are end-of-year estimates. Hence, we divide the profit flow figure of the given year by the fixed capital value of the preceding year in order to obtain the profit rate for the given year.

Net Fixed Capital Return = (Net Value Added - Labour Compensation)/Net Fixed Capital or alternatively:

$$\rho = \frac{Y - L}{K} \qquad (2),$$

where *Y* is the net value added, *L* is the total labour compensation, and *K* is the net stock of fixed assets. This profit measure is closer than any other to what could be measured as total surplus value as Marx defined it the 3rd Volume of *Capital*. One simple and efficient way to decompose the profit rate is the following, which has been previously proposed by Duménil and Lévy (1993). The equation that generally describes our broadest profit rate measure is equation (2), $\rho = \frac{\Pi}{K} = \frac{Y-L}{K}$. If we define *Y* as the total output of manufacturing sector, we could rewrite equation (2) as:

$$\rho = \frac{\Pi}{Y} * \frac{Y}{K} \qquad (3),$$

where Π/Y is the profit share in total output and Y/K is the output-capital ratio, otherwise referred to as capital productivity or maximum profit rate.[5] The first term explains how much income distribution, as the outcome of balance in class power and relations of production (labor productivity growth vis-à-vis wage growth), affects the movement of the rate of profit (Mohun, 2006). The second term, explains the influence of the dynamic development of productive forces and technological innovation (labor productivity growth vis-à-vis capital intensity growth) in the variation of the profit rate (Mohun, 2009). There is a wide array of papers that follow this empirical approach, which relies mainly on descriptive statistics and focuses primarily on the U.S. economy. The results of many of these studies have already been presented in the literature review section. It is not in our intentions to repeat this procedure for this paper, as we will choose a different empirical approach, more sophisticated in terms of modern time-series econometrics techniques, to answer our research question.

Equation (2) can be further modified as follows, in order to reach a higher level of decomposition from which we will derive the main variables that will be utilized in our time-series econometric model:

$$\rho = \frac{Y - L}{K} \Leftrightarrow$$

$$\rho = \frac{1 - \frac{L}{Y}}{\frac{K}{Y}} \Leftrightarrow \tag{4}$$

$$\rho = \frac{1 - \frac{L/N}{Y/N}}{\frac{K/N}{Y/N}} \tag{5}$$

where L/Y is the labour share of income, $1 - L/Y$ is the profit share of income, K/Y is the ratio of net fixed capital to income, N is the magnitude of employment in the manufacturing sector, *K/N* is the intensity of net fixed capital, i.e. the net fixed capital per

[5] If we assume that real wages or employee compensation were equal to zero, this would mean that the entire output *(Y)* of an economy would be profit. Thus, *Y/K* would be the maximum rate of net fixed capital return.

worker, L/N is the average labour compensation, and Y/N the labour productivity in the sector. The last three variables will be used as the independent variables in our econometric model together with the unemployment rate, which is used for theoretical reasons that have been outlined in the previous sections. The dependent variable will of course be the profit rate, i.e. the net fixed capital return, but we will present the econometric model in more detail in the following parts.

4.2. Qualitative and quantitative methodological issues

We do not make any distinction between productive and unproductive labour in this paper and we think that such a distinction is false. Many Marxist scholars have explained a decline in the rate of profit as the outcome a relative rise in unproductive labour vis-à-vis productive labour (e.g. Mohun, 2006; Moseley, 1992). According to this line of thought, value and surplus value is produced only when the new "use-values" are of material nature (Economakis et al., 2010). Thus, labour that is employed in trade or other services associated with circulation and supervision of the production process is unproductive because it does not produce new value but rather distributes and is paid from the value produced in the productive industries. This issue is as old as political economy and is present in the works of Smith, Ricardo, and Marx. It is true that Marx's works are also contradictory at points with regard to what is considered productive labour.[6] We do not embrace a "materialistic" interpretation of productive labour and thus consider all labour, where labour-power is exchanged for capital, as productive (Economakis et al., 2010). This means that we include all workers and branches of the

[6] *"Commercial capital thus creates neither value nor surplus value, at least not directly. Insofar as it contributes towards shortening the circulation time, it can indirectly help the industrial capitalist to increase the surplus value he produces. Insofar as it helps to extend the market and facilitates the division of labour between capitals, thus enabling capital to operate on a bigger scale, its functioning promotes the productivity of industrial capital and its accumulation. In so far as- it cuts down the turnover time, it increases the ratio of surplus-value to the capital advanced, i.e. the rate of profit. And insofar as a smaller part of capital is confined to the circulation sphere as money capital, it increases the portion of capital directly applied in production."* (Marx, 1991, pp. 392-393)

manufacturing industries regardless of whether they are directly associated with production, supervision, or circulation activities.

At this point, we need to outline some limitations of our analysis that require more laborious data work in order to be treated appropriately. First of all, the BEA data do not make any distinction between different types of labour income (wage, salary, benefits, bonuses etc.) nor do they disaggregate employee compensation further among different groups of working people, such as production or non-supervisory workers, middle-management, top executives etc.. This issue has serious implications since it is safe to assume that throughout time an increasing share of top executives' income is in essence profit income in the form of benefits, bonuses and so on. Especially after the mid-1990's there is an increasing share of income for high-profile executives that is in the form of dividends (Lapavitsas, 2011). This restriction may lead to an overestimation of wages in the manufacturing sector, thus augmenting the effect of this variable on the profit rate to a larger degree than its real contribution.[7]

Apart from that, our analysis excludes two groups of manufacturers that either do not fit the purpose of our research directly or relevant figures cannot be estimated quantitatively. These two groups are state-owned manufacturing companies that operate under a capitalist business regime (e.g. military industry) and individual producers who work independently with their own means of production and do not employ any wage labour, but still produce more than is required for their reproduction (what would be the average wage of an employee in the same industry), i.e. surplus value. State-owned capitalist enterprises are excluded because there is no industrial disaggregation for such companies in terms of different producing sectors. Thus, we would have to make some bold assumptions in order to retrieve the data just for the manufacturing companies, which would be rather risky considering the evolution of state intervention in the U.S. economy throughout this whole period. When it comes to sole proprietors, which is the term used by BEA for individual manufacturers, we decided to exclude them from our analysis not so much for methodological, but rather for theoretical reasons. We could distinguish their income into two parts, namely wage and profit, by using the average

[7] To see how some scholars have dealt with this issue see Duménil and Lévy (2011), Economakis et al. (2010), and Kliman (2012).

wage of the industry as proxy for their labour compensation and subtracting that from their total income to determine their profit. Their exclusion is based on the fact that, as individual owners of means of production who work themselves, they do not fit the classification of either worker nor capitalist. Their long-run profitability is not affected in the same manner by technical change, unemployment, or labour market developments as in the case of a typically capitalist manufacturing company that owns the constant capital and employs labour in order to produce profit. Furthermore, it is highly improbable that producers of this kind have any capacity for wide-scale innovation that can shift the techno-economic paradigm and yield significant labour productivity gains.

4.3. Econometric methods

4.3.1. Unit root tests

Formal unit root tests for stationarity will be utilized in order to check if our series can be used in econometric analysis without yielding spurious results due to trended data and secondarily in order to check the order of integration, which is a determining factor in how we proceed with the econometric analysis. Stationary time series experience only a temporary shift when an external shock occurs, after which they return back to their long-run mean (Asteriou & Hall, 2011, p. 267). The order of integration indicates the number of unit roots of a series, which is the minimum number of times it must be differenced to become stationary (Asteriou & Hall, 2011, p. 338).

We will test for unit roots using two tests, namely the Phillips-Perron (PP) test which has a null hypothesis of unit root and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test which has a reverse null hypothesis of stationarity (Kwiatkowski, Phillips, Schmidt, & Shin, 1992; Phillips & Perron, 1988). We use the default option of four Newey-West lags to compute the standard errors used in the PP test statistic in order to correct for autocorrelation. The KPSS test will be run under the null hypotheses of both trend stationarity and level stationarity, which are the default the alternative option respectively. The Schwert criterion is applied in order to determine the maximum lag order to be used in the calculation of the KPSS test (Kwiatkowski et al., 1992). Since we have a rather small sample (64 time observations), we have chosen to weigh autocovariances with the Quadratic Spectral kernel instead of the default Bartlett kernel used in KPSS, because it has been shown to yield better estimates of the long-run variance (σ^2) of the time series than other kernels in finite samples (Andrews, 1991; Hobijn, Franses, & Ooms, 2004; Newey & West, 1994). The rationale behind the use of both unit root tests is that they are complementary to each other because of their reverse "nature". The flexibility to test for both the presence of a unit root and stationarity as null hypotheses enables us to reach safer conclusions concerning the order of integration. This is very important because the order of integration defines to a great extent the empirical strategy to be followed in the subsequent analysis.

As a final point, we need to remind readers that unit root tests are widely considered to be of low power against the alternative hypothesis, as they are especially sensitive to the lag structure used to treat autocorrelation and to trend breaks (van Leeuwen & Foldvari, 2008). This is an additional reason why we use two unit root tests, i.e. to minimize the risk of Type I and II errors that would affect the statistical analysis, since it is based on pre-testing of the order of integration.

4.3.2. Multivariate cointegration analysis

Assuming that the results we obtain from the unit root tests indicate that the time series of our variables are generated by unit root processes which are integrated of order one, something one would normally expect from such kind of macroeconomic time series that do not cover a vast amount of time, we will proceed with the multivariate cointegration analysis. This will be the main part of our empirical analysis, which will be concluded with the estimation of a Vector Error Correction Model (VECM).

Granger (1981) was the one who first introduced the concept of cointegration, which would prove to be very significant for the progress of time series econometrics in the last thirty years, and has since been further developed by many econometricians. Cointegration occurs when two or more non-stationary time series that have similar stochastic trends can be jointly combined in order to eliminate non-stationarity and yield a stationary series that is $I(0)$ (Asteriou & Hall, 2011, p. 356). If we take the simplest possible model, that with two variables, and would like to express the cointegration relationship in statistical terms, we would say that: for two *I(1)* series, y_t and x_t, there may be a unique value of β for which $y_t - \beta x_t$ is *I(0)* (Hendry & Juselius, 2001). If we can statistically validate that there is at least one cointegration relationship between a set of *I(1)* variables, we can regress the variables in levels and obtain estimators without problems associated with spurious regressions. Apart from that, the mere existence of cointegration constitutes strong evidence in favor of a true long-run relationship between two or more variables. If the cointegration test reveals the existence of one or more cointegrating vectors, we will proceed with the estimation of a VECM.

In order to test for cointegration we will utilize the Johansen multiple-trace statistic procedure (Johansen, 1995). This test allows for multiple cointegration relationships, in contrast to the Engle-Granger test, and is necessary in our case since we have five variables. What is more, this test is considered to perform better than the alternative maximum eigenvalue test proposed by Johansen, because of higher robustness to skewness and excess kurtosis. In order to determine the appropriate lag length of the underlying VAR model we will choose the specification that minimizes the Akaike Information Criterion (AIC) in order to obtain Gaussian error terms that are normally distributed, homoscedastic, and not autocorrelated (Asteriou & Hall, 2011, p. 371). The maximum cointegrating rank, i.e. the maximum number of cointegrating vectors, in our case is $r = n - 1 = 4$, since we have five variables. Concerning the combination of deterministic components (intercepts/trends) that we will allow for in the cointegration relations and the underlying VAR, we will use model specifications “Case 2” and “Case 3” as presented in Hendry and Juselius (2001). Model specification 2 introduces a restricted trend in the cointegrating space and an unrestricted constant that allows for linear, but not quadratic, trends in the data. Model specification 3 still allows for an unrestricted constant, which means that are no deterministic linear trends in the cointegration equation, but there are still linear trends in the data.

4.3.3. Vector Error Correction Model

Our theoretical model (in logarithms) can be expressed as in the following equation:

$$lnr_t = \beta_0 + \beta_1 lnp_t + \beta_2 lnc_t + \beta_3 lnw_t + \beta_4 lnu_t + e_t \ ,$$

Where:
lnr_t: logged profit rate
lnp_t: logged labour productivity
lnc_t: logged capital intensity
lnw_t : logged average wage of full-time equivalent employee
lnu_t : logged unemployment rate
e_t: stationary error term

A general representation of the VECM containing all possible deterministic components (intercepts/trends) in the error correction term and the underlying VAR is given the following equation:

$$\Delta Y_t = \Gamma_0 + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + ... + \Gamma_{k-1} \Delta Y_{t-k-1} + \alpha(\beta' Y_{t-1} + \mu_1 + \delta_1 t) + \mu_2 + \delta_2 t + \varepsilon_t \quad (6),$$

Where:
Y_t: a vector of $I(1)$ variables
Γ_0: a $(n*1)$ vector of intercept terms with elements Γ_{i0}
Γ_i: a $(n*n)$ matrix containing φ_{ij} short-run coefficients
α : a $(n*r)$ matrix containing α_{ij} speed-of-adjustment coefficients
β': a $(r*n)$ matrix containing β_{ij} long-run coefficients
μ_1, $\delta_1 t$: intercept and trend in the cointegration equation
μ_2, $\delta_2 t$: intercept and trend in VAR
ε_t: a $(n*1)$ vector of error terms

In our case the Y_t vector will contain the five variables, while thee components of all other matrices and vectors will be determined by the specific models for each of the three sectors under examination (manufacturing total, capital-intensive, labour-intensive). As we see, the cointegration relationship has been introduced into the system of equations, thus accounting for its contribution. If we had not accounted for the long-run tendencies and instead estimated a VAR model in first differences it would suffer from omitted variable bias. The VECM provides a plethora of information concerning both short-term and long-term effects through the examination of the impact multipliers φ, the speed-of-adjustment parameters, α, and the beta parameters in the cointegrating equations, β.

In the case of a multivariate VECM where there are more than two cointegrating vectors, the problem of identification arises. This problem arises because at the presence of multiple cointegrating vectors any possible linear combination of these vectors is a cointegrating vector as well (Enders, 2008, p. 397). As Johansen himself had noticed, when there are two or more cointegrating vectors, what is estimated is the cointegration space that encompasses all possible vectors, and not the cointegration parameters (Asteriou & Hall, 2011, p. 393). In order to be able to identify the system and draw meaningful conclusions we need to place uniqueness restrictions on the cointegrating vectors based on economic theory. However, this problem will only concern us if we find the cointegration rank to be higher than one in any model. In the case of a single cointegrating vector, the only restriction that is necessary and sufficient in order to identify the cointegration equation is to assign an identity matrix to the first part of β, such that $\beta' = [I_r : \beta'_{(n-r)}]$, where $\beta'_{(n-r)}$ is a $((n - r)*r)$ matrix of identified parameters (Lütkepohl & Krätzig, 2004, p. 98). This is the normalization process proposed by Johansen, a method applied by default in most statistical software. For $r = 1$, this restriction translates to simply normalizing the coefficient of the first variable to be equal to unity. The choice of the variable that will be normalized must be based on economic theory and should not be made randomly, because there is always the chance that this specific variable does not enter the cointegration relation. Thus, the variable of choice should be significantly adjusting to the long-run relationship, information that can be drawn from the alpha coefficients. In our case, the obvious choice is normalizing on the coefficient of the profit rate, since we treat this variable as the “dependent”, based on economic theory.

5. Results

5.1. Unit root tests

Table 1 summarizes the results from the Philips-Perron (PP) test for the five variables, in log levels and first differences of the logs. As we had anticipated from theory and ocular inspection, all series are non-stationary in levels and are integrated of order one, *I(1)*, at least according to the PP-test results. The unemployment rate is common for all three sectors as it refers to the entire economy. We will now proceed to examine the results from the KPSS test using the same specifications.

Table 1. Phillips-Perron test results for log levels and their first differences

	Sector	Manufacturing	Capital-intensive	Labour-intensive
Variable	**H_0**	**Test statistic**	**Test statistic**	**Test statistic**
lnr	Non-Stationary, Trend	-1.41	-1.23	-2.76
Δlnr	Non-Stationary, Levels	**-8.15**	**-7.58**	**-7.57**
lnp	Non-Stationary, Trend	-0.79	-1.39	-3.43
Δlnp	Non-Stationary, Levels	**-7.11**	**-7.62**	**-10.22**
lnc	Non-Stationary, Trend	-2.41	-1.75	-1.54
Δlnc	Non-Stationary, Levels	**-6.82**	**-7.29**	**-6.14**
lnw	Non-Stationary, Trend	-3.38	-2.62	-2.65
Δlnw	Non-Stationary, Levels	**-8.14**	**-7.49**	**-8.51**
lnu	Non-Stationary, Trend	-3.14		
Δlnu	Non-Stationary, Levels	**-7.59**		

5% critical value is -2.92 and -3.94 for levels- and trend-stationary respectively.
Bold values of test-statistics are significant at the 5% level.

The results of the KPSS test, as presented in Table 2, are almost identical to those of the PP test. Notice that this time the null hypothesis is reversed compared to the PP test. The null hypothesis of trend stationarity can be rejected for all variables in levels, corroborating the results from the PP test.[8] We cannot reject the null of levels stationarity when examining the first differenced series apart from the case of the average wage in capital-intensive manufacturing industries. Wages in these industries fell sharply after the dot-com bubble exploded in 2001 and never entirely recovered before the strike of the recession in 2009. The average wage series in first differences displays a slight

[8] We have also tested for levels-stationarity for all the variables in log levels using both tests. The results are identical, however we think that testing for trend stationarity is more appropriate because every time series displays a clear trended pattern if not differenced.

downward trend and increasing variance over time. This may be an indication that this series could be possibly integrated of order two, as the KPSS test suggests. However, for the sake of our analysis, we will follow the results of the PP test (which strongly rejects the null of a unit root in first differences) and consider this variable to be also integrated of order one. In the next sub-section, we will proceed with the results from the multivariate cointegration testing.

Table 2. KPSS test results for log levels and their first differences

	Sector	**Manufacturing**	**Capital-intensive**	**Labour-intensive**
Variable	**H_0**	**Test statistic**	**Test statistic**	**Test statistic**
lnr	Trend Stationary	**1.21**	**1.29**	**0.466**
Δlnr	Levels Stationary	0.147	0.261	0.053
lnp	Trend Stationary	**1.06**	**0.956**	**0.151**
Δlnp	Levels Stationary	0.236	0.168	0.015
lnc	Trend Stationary	**0.329**	**0.822**	**0.398**
Δlnc	Levels Stationary	0.059	0.132	0.195
lnw	Trend Stationary	**0.624**	**1.019**	**0.547**
Δlnw	Levels Stationary	0.164	**0.677**	0.056
lnu	Trend Stationary		**0.374**	
Δlnu	Levels Stationary		0.043	

5% critical value is 0.463 and 0.146 for levels- and trend-stationary respectively.
Bold values of test-statistics are significant at the 5% level.

5.2. Cointegration testing

The results that we derived from the Johansen trace statistic tests concerning the number of cointegrating vectors are presented in Table 3Table 4 below. As one will easily notice, the results for all sectors in both models are the same and are quite straightforward in their interpretation. In Table 3, where the models include a linear trend in the cointegrating space, we can see that the null hypothesis of no cointegration is rejected at the 5% level of significance for all three sectors. The null hypothesis of at most one cointegration relation cannot be rejected in any of the three sectors, thus we conclude that there is one cointegrating vector in each of these three models. This result proves that there is at least one true long-run relationship between the set of variables under investigation.

Table 3. Johansen trace test results, "Case 2" model specification (unrestricted constant & linear trend restricted in the cointegration space)

Sector	#CI vectors under H_0	Trace statistic	5% critical value	Conclusion
Manufacturing	0	111.43	87.31	Reject H_0
	≤ 1	56.89*	62.99	H_0
Capital-intensive	0	99.09	87.31	Reject H_0
	≤ 1	53.81*	62.99	H_0
Labour-intensive	0	127.25	87.31	Reject H_0
	≤ 1	59.35*	62.99	H_0

Table 4 presents the results for the models that do not contain a linear trend in the cointegrating space but only an unrestricted constant. The results obtained here are identical to those for "Case 2" model specification. The null hypothesis of no cointegration is rejected at the 5% level of significance for all three sectors. On the contrary, the hypothesis of at most one cointegration relation cannot be rejected in any of the three sectors and the conclusion remains that there is one cointegrating vector in each of these three models. Thus, the problem of identification is not present in any of the models and it will not be necessary to impose additional restrictions, other than the normalization process, on the coefficient matrices α and β in order to uniquely define them and restore statistical inference. The results for the coefficients from the VECM estimation will be presented in the next section.

Table 4. Johansen trace test results, "Case 3" model specification (unrestricted constant)

Sector	#CI vectors under H_0	Trace statistic	5% critical value	Conclusion
Manufacturing	0	92.57	68.52	Reject H_0
	≤ 1	39.63*	47.21	H_0
Capital-intensive	0	76.94	68.52	Reject H_0
	≤ 1	42.13*	47.21	H_0
Labour-intensive	0	106.11	68.52	Reject H_0
	≤ 1	38.29*	47.21	H_0

5.3. VECM Estimation

Table 5,Table 6, and Table 7 report the estimates for the speed-of-adjustment parameters, α, and the cointegrating vectors, β, for the two model specifications that we defined earlier and for each sector separately. We will not report results or tests on the short-run coefficients φ because in most models they are statistically insignificant and are not directly related to our research question.

Table 5 summarizes the results for the manufacturing sector in total. We see that in both models, the average wage and labour productivity do not significantly respond to the long-run equilibrium error and their value is close to zero. This denotes that these variables can be thought of as weakly exogenous in the long-run, which means that they are affected by a variety of other factors that are not included in this model. We re-estimated the models with the restriction on these two alpha coefficients to be strictly zero, and the results regarding the beta coefficients did not alter significantly, which is further indication of long-run weak exogeneity. This result designates that the long-run (endogenous) equations of these variables can be dropped, but they will still be a part on the right hand side of the all other cointegration equations.[9] We see that the profit rate, the capital intensity, and the unemployment rate adjust significantly to a discrepancy in the long-run equilibrium, with the unemployment rate exhibiting the highest negative adjustment under both model specifications. This alpha coefficient indicates that in the case of a positive (negative) deviation from the long-run relationship the unemployment rate will decrease (increase) and vice versa. The size of the alpha coefficient shows how much of the adjustment to equilibrium occurs in each period, a year in this case. In the first model, the profit rate adjusts by increasing 49% to a positive deviation from equilibrium in a year. The results of the second model are similar, thus the same conclusions and normalization process apply as well.

Table 5. Parameter estimates for models in Table 3 and Table 4, Manufacturing Sector

Variable	*lnr*	*lnc*	*lnw*	*lnp*	*lnu*	*trend*
Restricted Trend						
α	0.49*	-0.31**	0.066	0.042	-2.37***	—
β	1	0.48***	1.21**	-1.83***	0.26***	0.007*
Unrestricted Constant						
α	0.64*	-0.48***	0.039	-0.001	-3.29***	—
β	1	0.73***	1.22**	-1.86***	0.18**	—

*p<0.5, **p<0.01, ***p<0.001

[9] In this case this does not really affect our analysis, since based on our theoretical assumptions we are interested in the long-run equation that features the profit rate on the left had side and all other variables on the right hand side.

All long-run beta coefficients in both models, as well as the trend term in the first model are statistically significant. We choose to normalize on *lnr*, since this choice is also supported by theoretical reasons as we have outlined previously. The long-run equation for *lnr* in each model can be written as a function of long-run elasticities, using the beta coefficients of the other variables, since all of them are in logarithms, as follows:

$$\Delta lnr = -1.52 - 0.48\Delta lnc - 1.21\Delta lnw + 1.83\Delta lnp - 0.26\Delta lnu - 0.007t \qquad \textit{Restricted trend}$$

$$\Delta lnr = -0.85 - 0.73\Delta lnc - 1.22\Delta lnw + 1.86\Delta lnp - 0.18\Delta lnu \qquad \textit{Unrestricted constant}$$

We see that the signs and magnitudes of the coefficients in both models are almost identical. Capital intensity, the average wage, and labour productivity enter the profit rate equation with the expected sign, in contrast to unemployment. The trend term is significant at the 5% level, however its magnitude (decline of 0.7% per annum) does not point to a secular declining trend in the profit rate. The impact of labour productivity on the profit rate is the largest, as expected, indicating that a 1% change in labour productivity would increase the profit rate by approximately 1.85% in both models. Capital intensity and the average wage also exert a significant negative influence on the profit rate as anticipated.

Table 6 presents the parameter estimates concerning the capital-intensive industries of the manufacturing sector. In the model that imposes a trend restricted to the cointegration space, we find that capital intensity and unemployment do not significantly adjust to the long-run equilibrium. In the second model (unrestricted constant), the result is the same as in the manufacturing sector, pointing to labour productivity and real wages as the weakly exogenous variables.

Table 6. Parameter estimates for models in Table 3 and Table 4, Capital-intensive Manufacturing

Variable	*lnr*	*lnc*	*lnw*	*lnp*	*lnu*	*trend*
Restricted Trend						
α	-0.41*	-0.036	-0.21***	-0.32***	0.31	—
β	1	1.44***	1.25***	-1.13***	-0.11*	-0.034***
Unrestricted Constant						
α	0.71*	-0.39***	-0.037	0.192	-4.31***	—
β	1	0.81***	0.76***	-1.47***	0.11**	—

*p<0.5, **p<0.01, ***p<0.001

Since the alpha coefficient of the profit rate is significant, we choose to normalize on the variable of interest again. When it comes to the long-run equations, all beta coefficients and the trend term in the first model are statistically significant at the 5% level. The cointegration equations for the two model specifications normalized for *lnr* are:

$$\Delta lnr = -4.44 - 1.44\Delta lnc - 1.25\Delta lnw + 1.13\Delta lnp + 0.11\Delta lnu + 0.034t \qquad \textit{Restricted trend}$$

$$\Delta lnr = -0.65 - 0.81\Delta lnc - 0.76\Delta lnw + 1.47\Delta lnp - 0.11\Delta lnu \qquad \textit{Unrestricted constant}$$

The negative long-run contribution of capital intensity is larger in these industries compared to total manufacturing, as was anticipated, signifying a stronger tendency towards falling profitability with capital deepening. The elasticity of average real wages is again negative, although lower in the second model. Labour productivity enters the equation again with a positive sign, but with somewhat lower influence compared to total manufacturing. This result is also in line with the findings of Beitel (2009) and Duménil and Lévy (2002b) who argue that in these industries it is capital productivity rather than labour productivity that affects the profit rate the strongest. Nevertheless, in the model with an unrestricted constant it remains the variable with the highest impact on profit rate. The unemployment rate has a marginal positive effect in the first model, in contrast to that without the trend term where its contribution is negative, which is hard to interpret with the rationale that we presented earlier. Unemployment remains the variable with the smallest long-run influence on the profit rate, as in total manufacturing. The trend term indicates that the profit rate increases autonomously at a rate of 3.4% per year, which contrasts the notion of a secular declining trend. This could potentially be interpreted as a proxy for productivity gains that captures the influence of large-scale innovations.[10]

Finally, Table 7 displays the parameter estimates of the models dealing with labour-intensive manufacturing industries. Starting from the alpha coefficients, we notice that this is the only sector where capital intensity does not significantly adjust to the cointegration relationship in both models. This is an indication that capital intensity in this sector is weakly exogenous and that it is of minor importance to the long-run

[10] This interpretation of the trend term is based on the estimation of a similar VECM by Lütkepohl and Krätzig (2004, pp. 191-192).

equilibrium with the rate of profit. Contrary to our expectations, the same is true for average real wages despite this being a sector where the compensation of labour is a larger part of the total output. This is probably an indication that real wages, especially in this sector, are determined by a wide variety of factors (unionization, international competition, etc.) that are not part of this model. Labour productivity, unemployment rate, and rate of profit adjust significantly to the equilibrium error and we choose to normalize the long-run relation on the last once more.

Table 7. Parameter estimates for models in Table 3 and Table 4, Labour-intensive Manufacturing

Variable	*lnr*	*lnc*	*lnw*	*lnp*	*lnu*	*trend*
Restricted Trend						
α	-0.49*	-0.151	-0.048	-0.22*	1.18***	—
β	1	1.57***	-0.215	-2.59***	-0.55***	0.002
Unrestricted Constant						
α	-0.49*	-0.143	-0.055	-0.22**	1.16***	—
β	1	1.61***	-0.283	-2.46***	-0.56***	—

*p<0.5, **p<0.01, ***p<0.001

The cointegration equations for the two models, normalized on *lnr,* are the following:

$$\Delta lnr = -6.61 - 1.57\Delta lnc + 0.22\Delta lnw + 2.59\Delta lnp + 0.55\Delta lnu - 0.002t \qquad \textit{Restricted trend}$$

$$\Delta lnr = -6.34 - 1.61\Delta lnc + 0.28\Delta lnw + 2.46\Delta lnp + 0.56\Delta lnu \qquad \textit{Unrestricted constant}$$

The beta coefficients of the real wage in both models, as well as the trend term in the first model are not significant at conventional levels. Capital intensity has the largest so far negative contribution in both models, which indicates that capital deepening in labour-intensive manufacturing is more detrimental for profitability in the long run, in contrast to what we had expected. The real wage enters the equation with the wrong sign in both models, but the betas are statistically insignificant. Labour productivity exhibits the largest so far positive contribution in both models, which highlights the importance of labour productivity gains for the boost of profitability in these industries. Finally, the unemployment rate seems to confirm in these models its role as a mean to control wage growth and boost the profit rate, as we stressed in the theoretical part, by exhibiting a positive influence in both models. It also confirms our hypothesis that unskilled labour, which is the norm in labour-intensive industries, is more vulnerable and manageable than the better-equipped employees of the capital-intensive industries.

6. Conclusion

Our literature review highlighted a scarcity of academic papers that examine the determining factors of long-term profitability in the manufacturing sector with the use of advanced econometric techniques. The vast majority of scholars that have taken part in the debate concerning long-run profitability dynamics analyze economy-wide datasets by means of descriptive, visual, exploratory, or decomposition methods (or a combination of the above). In this paper, the attempt was made to follow a different approach by focusing on the U.S. manufacturing sector, while extending our research to account for any diverging patterns in capital-intensive and labour-intensive manufacturing industries. We designed our theoretical model and formulated testable hypotheses based on the concepts of Marx-biased technical change and the law of the tendential fall in the rate of profit. The basic notion deriving from these two concepts is that during the process of development in capitalist economies, the urge of the individual company/entrepreneur to increase her profits will lead to capital-deepening/labour-substituting technical bias that will take sectoral profit rates down if specific counteracting forces, which we control for in our model, do not come into play.

The empirical strategy that was followed originates in the thorough analysis of the statistical properties of our time series, and more specifically in the fact that they are generated from unit root process. Since the variables in our model were found to be integrated of order one, we decided to proceed with multivariate cointegration testing, allowing for both an unrestricted constant and a trend term restricted to the cointegration space respectively. Both model specifications imply linear trends in the levels data, while the latter also allows for a linear trend in the cointegration equation. The result of the Johansen trace test statistic suggested the existence of one cointegration vector, in all sectors, and under both model specifications. Subsequently, we proceeded with the estimation of a VECM for each sector and model specification.

The long-term effect of capital intensity on the profit rate was significant and negative for all sectoral subdivisions, irrespective of the model specification, providing evidence that capital deepening is detrimental for profitability in the long term. Its effect was larger in labour-intensive manufacturing industries in contrast to our expectations. The influence of real wages on the profit rate was also found to be negative in manufacturing and capital-intensive industries, whereas in labour-intensive manufacturing its effect was insignificant at standard levels of statistical inference. The negative contribution of real wages was stronger in total manufacturing compared to capital intensity, which dominated in capital-intensive industries. The long-run effect of labour productivity was positive and greater compared to that of the other variables in all models. Its magnitude was higher in labour-intensive and total manufacturing than in capital-intensive manufacturing, emphasizing the role of labour productivity gains (as opposed to capital productivity gains) stemming from technical change in boosting profitability.

Additionally, the findings concerning the influence of the unemployment rate on the rate of profit were ambiguous and harder to interpret. In total manufacturing, it is negatively related with the profit rate evolution. Only in labour-intensive manufacturing it displays a clear positive impact on the rate of profit in both models and thus seems to operate as a measure to control wage growth and discipline labour, as we discussed in the theoretical part. This result also verifies our hypothesis that a worker in labour-intensive manufacturing, who is usually unskilled, is more susceptible to external pressures, such as international competition, that manifest themselves through unemployment. Finally, we found a significant negative trend term in total manufacturing. However, its magnitude was rather small and was not deemed as sufficient to conclude that there is a secular declining trend in the rate of profit. The rate of profit in capital-intensive manufacturing displayed a significant positive trend.

To conclude with, we need to emphasize that the modeling of all possible contributing factors can be extended, in order to fully capture the long-run determinants of the profit rate. One significant methodological improvement that remains as a task for the future is the analysis of the sector with the inclusion of one or more structural breaks.

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Appendix A – Data sources

1. BEA – GDP-by-Industry Tables

GDPbyInd_VA_SIC: Value Added by Industry, Gross Output by Industry, Intermediate Inputs by Industry, the Components of Value Added by Industry, and Employment by Industry

2. BEA NIPA – GDP & Income Tables

Table 1.1.9. Implicit Price Deflators for Gross Domestic Product: GDP Deflator

Table 6.5B.-D. Full-Time Equivalent Employees by Industry

Table 6.6B.-D. Wages and Salaries per Full-Time Equivalent Employee by Industry

BEA NIPA – Fixed Asset Tables

Table 3.1ESI. Current-Cost Net Stock of Private Fixed Assets by Industry

3. BLS – Labor Force Statistics from the Current Population Survey

Unemployment rate, Series ID: LNS14000000, Seasonally Adjusted, 16 years and over