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ABSTRACT

This study estimates productivity gains and their distribution among inputs and outputs for American industries over the period 1987-2011 using the traditional surplus accounting method. Total Factor Productivity (TFP) change is traditionally defined as the growth rate of output minus the growth rate of inputs. Since TFP changes determine welfare via price variations, a key issue is to assess which of the inputs and outputs recover price advantages.

Our analyses were carried out in two steps. The initial analysis was conducted at the aggregate level from a bottom-up approach based on 63 different sectors of the US economy. Over the twenty four years (1987-2011), US TFP increased at an average annual rate of 0.9% due to 2.7% growth in gross output while input volume increased by only 1.8%. Our study demonstrates that remunerations to employees and firms’ profitability constituted 51% and 38%, respectively, of the accumulated economic surplus from the productivity gains over the last 24 years. However there is one significant caveat to that average result: the price advantage for employees has been essentially captured by the top income earners and most American workers have not benefited from productivity gains during the last decade, resulting in the current debate about the wide income disparities in USA. Suppliers of intermediate inputs retained 11.5% of the surplus, corresponding to a slight positive trend in their respective prices. Finally, customers, equipment and structure providers were the losers in the distribution of economic surplus via respectively, a significant growth of relative final demand prices and a substantial price decrease of these assets.

A second step analysis developed at the sectoral level showed that industries with high TFP growth rates mainly benefited customers and firms via output price decreases and profitability improvements while industries with low or negative TFP changes clearly hurt customers through significant output price increases. The sectoral level analysis also showed that employees ’remunerations are independent of productivity gains produced within their industrial sectors.

Keywords: Surplus Accounting Method, Total Factor Productivity, Factor Income Distribution, Index Numbers

JEL codes: C43, D24, D33

1. INTRODUCTION

Productivity growth strongly impacts standard of living through real price changes. In this way, measuring productivity gains is only one side of the economic growth story. Special attention should also be paid to the distribution of productivity gains among the stakeholders participating in the production process.

For a long period, this last question has been considered as a key issue in productivity analysis. Kendrick (1961), Kendrick and Sato (1963), devoted a large part of their works to measure generation and distribution of TFP growth from quantity and price variations simultaneously. In recent years TFP estimations have been an extraordinarily innovative field of research (Hulten et al., 2001; Fried et al., 2008). However, very little attention has been focused on the distribution of the gains from Total Factor Productivity through price effect components (Grifell-Tatej, Lovell, 1999).

Nevertheless, it seems crucial to include both generation and distribution of TFP changes in the debate on industrial policies. Since many governments interfere with market prices and provide supports to producers and customers, value advantages stemming from growth in TFP should be taken into account by policies designed to control prices and deliver subsidies. For example, if automobile producers are able to retain a significant share of their productivity gains through increased profitability, subsidies could be adjusted downwards over time in a relatively painless way for this industry. Conversely, if producers do not benefit from productivity gains because they face high production costs and lower profit levels it could be justified in the short run to augment direct payments to producers in the form of tax breaks.

During the sixties and the seventies, such analyses became a standard practice. Particularly, one can mention the studies conducted by CERC[1]. This French research institution developed numerous case-studies aimed at analyzing the distribution of productivity gains generated by the big French public companies among their different stakeholders as employees, suppliers, government, lenders, shareholders or clients (CERC, 1980).

Following CERC’s approach namely, “surplus accounting method”, this paper proposes to evaluate the TFP growth and its combined effects on output and input price variations for the American economy over the last twenty four years. In a first step, a bottom-up approach based on 63 different industries estimates TFP rates as the difference between output and input quantity changes, based on the surplus accounting method and the use of superlative additive indexes. Simultaneously, this Productivity Surplus (PS) is divided into its price change components in order to determine the stakeholders who do or do not receive price advantages from technical innovations, improvements in efficiency, and better management. A second step analysis attempts to characterize the distribution of price advantages according to the TFP growth rates previously estimated at the sectoral level.

The rest of the paper is organized as follows. Section 2 presents the surplus accounting method, its superlative quantity and price additive indicators necessary to measure and to distribute the productivity surplus. Section 3 estimates TFP changes and describes how they are decomposed into output and input price advantages for the whole American economy. Section 4 analyses the correlation between TFP evolutions and the structure of their distributions among the different stakeholders at the industry level. Section 5 summarizes our conclusions.

[1] Centre d’Etudes des Revenus et des Coûts

2. GENERATION AND DISTRIBUTION OF PRODUCTIVITY SURPLUS

Surplus accounting

Surplus accounting provides an extension of the index number approach by describing how the economic surplus resulting from productivity growth is shared between the various agents (Kendrick and Sato, 1963; Courbis and Temple, 1975; CERC, 1980). Retaining J different outputs produced from I different inputs, one can simply define the operating surplus as the residual profit expressed in real terms[2]:

$$\Pi = \sum_{j=1}^{J} p_j y_j - \sum_{i=1}^{I} w_i x_i \quad (1)$$

with p_j real price of output y_j and w_i real price of input x_i

Considering that the total output value is distributed into returns to the I different inputs and the operating surplus, the following accounting identity holds for any particular industry:

$$\sum_{j=1}^{J} p_j y_j = \sum_{i=1}^{I+1} w_i x_i \quad (2)$$
$$with\ \Pi = w_{I+1} X_{I+1}$$

One can note that the residual profit, Π, is therefore explicitly defined as a cost $w_{I+1} X_{I+1}$ which remunerates a specific input X_{I+1} including dividends, interest costs or managers' remunerations before tax. This can be approximated by the net operating surplus (gross operating surplus minus consumption of fixed capital) and evaluates the ability of an industry to generate a financial surplus after covering the costs of intermediate consumptions and primary inputs (labor and fixed capital).

The difference in equation (2) between period t and period s leads to:

$$\sum_{j=1}^{J} p_j^t y_j^t - \sum_{j=1}^{J} p_j^s y_j^s = \sum_{i=1}^{I+1} w_i^t x_i^t - \sum_{i=1}^{I+1} w_i^s x_i^s \quad (3)$$

Given equation (3), changes in the output and input values between two periods can be expressed in terms of changes in quantities and prices. Considering that $p_j^t = (p_j^s + dp_j)$, $y_j^t = (y_j^s + dy_j)$, $w_i^t = (w_i^s + dw_i)$ and $x_i^t = (x_i^s + dx_i)$, equation (3) can be transformed as:

$$\sum_{j=1}^{J} (p_j^s + dp_j)(y_j^s + dy_j) - \sum_{j=1}^{J} p_j^s y_j^s = \sum_{i=1}^{I+1} (w_i^s + dw_i)(x_i^s + dx_i) - \sum_{i=1}^{I+1} w_i^s x_i^s$$

$$\sum_{j=1}^{J} p_j^s y_j^s + \sum_{j=1}^{J} p_j^s dy_j + \sum_{j=1}^{J} dp_j y_j^s + \sum_{j=1}^{J} dp_j dy_j - \sum_{j=1}^{J} p_j^s y_j^s = \sum_{i=1}^{I+1} w_i^s x_i^s + \sum_{i=1}^{I+1} w_i^s dx_i + \sum_{i=1}^{I+1} dw_i x_i^s + \sum_{i=1}^{I+1} dw_i dx_i - \sum_{i=1}^{I+1} w_i^s x_i^s$$

$$\sum_{j=1}^{J} p_j^s dy_j + \sum_{j=1}^{J} dp_j (y_j^s + dy_j) = \sum_{i=1}^{I+1} w_i^s dx_i + \sum_{i=1}^{I+1} dw_i (x_i^s + dx_i)$$

And after simplification and re-arrangement, it leads to equation (4)

$$\sum_{j=1}^{J} p_j^s dy_j - \sum_{i=1}^{I+1} w_i^s dx_i = -\sum_{j=1}^{J} dp_j y_j^t + \sum_{i=1}^{I+1} dw_i x_i^t \quad (4)$$
$$PS = PA$$

[2] Nominal input and output prices are deflated by a general price index such as the GDP price index

where the left hand side represents the productivity surplus (PS) defined as the difference between price weighted changes in output and input quantities. The right hand side measures the sum of price advantages (PA). The price advantage or remuneration change over the two periods for any stakeholder is equal to the difference between the quantity weighted changes in its related output or input price[3]. Such price variations result in transfers between agents that add to the value of the productivity surplus. More fundamentally, equation (4) means that the sum of remuneration changes distributed among the different stakeholders (PA) cannot exceed the total productivity growth (PS). By regrouping positive price advantages on the left hand side and on the right hand side, *PS* with all price disadvantages (negative price advantages in absolute value), one can establish the following balanced productivity surplus account (table 1):

"place table 1 here"

The productivity surplus can be negative (productivity losses). In such a case, since the equality between PS and PA has to be maintained in equation (4), the productivity losses have to be compensated through increases in some output prices or decreases in some input costs.

Overall, the various changes in quantities and prices correspond to either an "origin" (resources) or a "distribution" (uses) of the total economic surplus. For instance, production accounts available at the American industry level allow for the decomposition of value changes into quantity and price effects. This enables us to analyze all the corresponding transfers among customers, suppliers of intermediate inputs (energy, raw material), employees, fixed assets (equipment, software, structures and buildings). Table 2 depicts the corresponding transfers.

"place table 2 here"

Productivity surplus (PS), Price advantages (PA) and Total Factor Productivity (TFP)

With equation (4), productivity gains (PS) are defined as the difference between output and input quantity variations expressed in level terms (i.e. in dollars). They can also be directly equated to the usual Solow technical change residual as a measure of TFP growth rate expressed in relative terms (%). Let us define the traditional underlying multi-output and multi-input production function:

$$\begin{gathered} F(\text{y},\text{x},t)=0 \\ \text{with t a time trend} \\ \text{and x, y input and output vectors respectively} \\ \text{x}=(x_1,x_2,...,x_i,...,x_{I+1}) \\ \text{y}=(y_j,y_2,...,y_j,...,y_J) \end{gathered} \quad (5)$$

From equation (5), and assuming output prices equal to marginal costs and equating input prices to the marginal productivity returns, the Solow residual defining TFP growth rate over time can be estimated as the weighted output variations not explained by weighted input changes:

[3] An input price increase is considered as a price advantage for the corresponding input (its remuneration is increasing) while an output price decrease has to be considered as a price advantage for the customer (output price is becoming cheaper).

$$\frac{dTFP}{TFP}=\sum_{j=1}^{J}\alpha_j\frac{dy_j}{y_j}-\sum_{i=1}^{I+1}\beta_i\frac{dx_i}{x_i} \quad (6)$$

where α = vector of the J output shares in total revenue and β =vector of the *I+1* input shares in total cost.

Replacing $\alpha_j\frac{dy_j}{y_j}$ by $\frac{p_j dy_j}{\sum_{j=1}^{J}p_j y_j}$ and $\beta_i\frac{dx_i}{x_i}$ by $\frac{w_i dx_i}{\sum_{i=1}^{I}w_i x_i}$ and considering that the total revenue equals the total cost ($\sum_{j=1}^{J}p_j y_j=\sum_{i=1}^{I+1}w_i x_i$), TFP growth rate becomes:

$$\frac{dTFP}{TFP}=\frac{\sum_{j=1}^{J}p_j dy_j-\sum_{i=1}^{I+1}w_i dx_i}{\sum_{j=1}^{J}p_j y_j} \quad (7)$$

This represents the productivity surplus rate defined as PS from equation (4) divided by the total output value.

Moreover, one can establish an interesting link between TFP growth rate and price advantage changes. Through the equality between PS and PA, TFP rate is just equal to the summation of price advantage rates (defined as the ratio between price advantages and the total output value):

$$\frac{dTFP}{TFP}=\frac{PS}{\sum_{j=1}^{J}p_j y_j}=\frac{PA}{\sum_{j=1}^{J}p_j y_j}=\frac{-\sum_{j=1}^{J}dp_j y_j^t+\sum_{i=1}^{I+1}dw_i x_i^t}{\sum_{j=1}^{J}p_j y_j} \quad (8)$$

A Bennet based productivity surplus decomposition

In equation (4), *PS* is defined as Laspeyres output and input quantity changes weighted by price levels from initial period s while *PA* is equal to Paasche output and input price variations weighted by quantity levels from final period t. These two components can be similarly defined through Paasche quantity changes and Laspeyres price variations respectively:

$$\sum_{j=1}^{J}p_j^t dy_j-\sum_{i=1}^{I}w_i^t dx_i=-\sum_{j=1}^{J}dp_j y_j^s+\sum_{i=1}^{I}dw_i x_i^s$$
$$PS^{Paasche}=PA^{Laspeyres}$$

The equivalent relationship could be expressed in terms of a Bennet additive index which relies on an arithmetic average of the two Laspeyres and Paasche expressions of PS and/or PA

$$\sum_{j=1}^{J}\left(\frac{p_j^t+p_j^s}{2}\right)dy_j-\sum_{i=1}^{I}\left(\frac{w_i^t+w_i^s}{2}\right)dx_i=-\sum_{j=1}^{J}dp_j\left(\frac{y_j^t+y_j^s}{2}\right)+\sum_{i=1}^{I}dw_i\left(\frac{x_i^t+x_i^s}{2}\right)$$
$$\frac{1}{2}\left(PS^{Laspeyres}+PS^{Paasche}\right)=\frac{1}{2}\left(PA^{Paasche}+PA^{Laspeyres}\right) \quad (9)$$
$$PS^{Bennet}=PA^{Bennet}$$

This productivity surplus decomposition does not depend on any arbitrary choice between the two periods. It can be referred to as the superlative index concept, notably the Fisher, while the additivity property of the aggregation formula enables the decomposition of value changes into price and quantity effects in level terms. While this Bennet based productivity surplus decomposition has not received a great deal of attention in the literature, its usefulness can be proven. As stressed by Diewert (2005), dealing with profit or, in this case, with production accounts means retaining additive decomposition since the change of output value is defined as the addition of cost changes in value terms. While the traditional Fisher index is based on a multiplicative decomposition, the Bennet indicator is additive[4] and presents the same relevant properties of equicharacteristicity[5]. We refer to Diewert (2005) for a thorough discussion of the properties and merits of each type of index in various economic contexts. For revenue or cost and profit decomposition, Diewert unequivocally favors the Bennet indicator (Bennet, 1920) which appears as the most appropriate tool.

The basis of the decomposition of any value change between two periods s and t as: $p^t y^t - p^s y^s$ into price and volume effects can be illustrated by a graphical representation largely inspired by Diewert (2005).

"place figure 1 here"

Figure 1 presents, the two output values at periods *t* and *s* in the quantity/price space. The red rectangle defines the output value at date *s* and the larger rectangle defines the one at period *t*. The value change is illustrated by the area between these two rectangles, i.e., the visible blue part. Any decomposition of this area leads to a decomposition of the output value change. The one proposed by Bennet is the following: draw a segment between points B and A and compute the two related areas. The area attached to the quantity axis represents the volume effect and the area attached to the price axis the price effect. As illustrated above, several kinds of decompositions can be conceived but, as shown by Diewert, the one proposed by Bennet is probably the best and the most useful due to its numerous interesting properties.

Additionally, Caves et al (1982) have shown that the Bennet indicator closely approximates the true TFP change that is as much defensible as the Fisher index which is considered as the most general and satisfactory index (Diewert, 1992). In practice, both measures lead to extremely similar results (and so does the Törnqvist index). This has been observed by all users who have made empirical comparisons of index numbers in time series as well as in cross section analyses (see for example Bureau et al, 1990).

Finally, through the additivity property of PS, the real value (or volume) of an aggregate is equal to that obtained by adding the volume components at any aggregation sub-level. More precisely, the productivity surplus of any aggregation of N industries is equal to the sum of the N productivity surpluses measured at the sectoral level:

$$PS_{\text{of agregation}} = \sum_{n=1}^{N} PS_n \quad (10)$$

[4]The additivity property means that the real value (or volume) of an aggregate is equal to that obtained by adding the real values of the components at any aggregation sub-level.
[5]This property states that an index should not be dependent on the basket of goods of one particular period.

Therefore, the TFP growth rate at the aggregated level is just equal to the weighted arithmetic mean of the N individual TFP growth rates:

$$\frac{dTFP}{TFP}_{\text{of agregation}} = \frac{\sum_{n=1}^{N} PS_n}{\sum_{n=1}^{N} \mathrm{p_n}\mathrm{Y}_n} = \sum_{n=1}^{N} \frac{PS_n}{\sum_{n=1}^{N} \mathrm{p_n}\mathrm{Y_n}} = \sum_{n=1}^{N} \frac{\mathrm{p_n}\mathrm{Y}_n}{\sum_{n=1}^{N} \mathrm{p_n}\mathrm{Y}_n}\left(\frac{PS_n}{\mathrm{p_n}\mathrm{Y_n}}\right) = \sum_{n=1}^{N} \frac{\mathrm{p_n}\mathrm{Y_n}}{\sum_{n=1}^{N} \mathrm{p_n}\mathrm{Y_n}}\left(\frac{dTFP}{TFP}\right)_n$$

with $\mathrm{p_n}$ = line price vector and Y_n = column quantity vector of J outputs of sector n

$$\Rightarrow \frac{dTFP}{TFP}_{\text{of agregation}} = \sum_{n=1}^{N} \omega_n \left(\frac{dTFP}{TFP}\right)_n \qquad (11)$$

$$\text{with } \omega_n = \frac{\mathrm{p_n}\mathrm{Y_n}}{\sum_{n=1}^{N} \mathrm{p_n}\mathrm{Y_n}}$$

In the aggregate productivity process, equation (11) does not take flows of some specific inputs between industries (such as intermediate inputs) into account. In fact at the macroeconomic level, aggregate TFP increase is reinforced by induced effects due to integration since downstream activities may profit from productivity gains of firms that deliver intermediate products. Such effects can be captured by Domar (1961) weights which are measured by ratio of each industry's gross output to economy-wide value added. The sum of these weights surpasses 100% and highlights that productivity growth in an upstream industry has both direct and indirect effects on economy-wide productivity change (Jorgenson, Schreyer, 2013).

As clearly demonstrated by OECD (2001), a comparison with equation (11) establishes that, at the macroeconomic level, TFP change can be differently calculated as a weighted sum of industry level productivity growth. Each industry productivity growth given by equations (6) or (7) is weighted by the ratio of its gross output to total value-added or equivalently to total income of primary inputs (labor and fixed capital). Moreover since for any industry n, the value-added and gross output productivity based measures are linked by a coefficient equal to the inverse share of value added in gross output value, the aggregate TFP change is likewise equal to a weighted average of value-added based productivity measures.

$$\frac{dTFP}{TFP}_{\text{of agregation}} = \sum_{n=1}^{N} \psi_n \left(\frac{dTFP}{TFP}\right)_n^{gross-output} = \sum_{n=1}^{N} \eta_n \left(\frac{dTFP}{TFP}\right)_n^{value-added}$$

$$\text{with } \psi_n = \frac{p_n Y_n}{\sum_{n=1}^{N} VA_n} \text{ and } \eta_n = \frac{VA_n}{\sum_{n=1}^{N} VA_n} \qquad (12)$$

As a result, aggregate TFP growth rate in (11) is always lower than this estimated in (12). This is not a bias but leads to an interpretation which differs from the value-added productivity measure established at the macroeconomic level. Although the former aggregate approach excludes induced effects due to integration process, it has an analytical meaning. Additionally, as a simple weighted average of industry-level productivity, it allows us to include the intermediate input suppliers in the average distribution of TFP gains among US industries which is not possible through the value-added based TFP approach.

3. TFP GAINS AND PRICE ADVANTAGES FOR AMERICAN INDUSTRIES

The data

This study focuses on productivity gains generated by American industries. Value, quantity and price indexes were collected from the production accounts published by the Bureau of Economic Analysis (BEA)[6]. The production accounts are expressed in current US dollars and in quantity or price indexes (base year 100=2005) for 63 different industrial sectors for the period 1987-2011. The output is measured by the gross output net of taxes on production less subsidies while the input vector contains 4 explicit inputs (intermediate inputs, labor, equipment and software, structure). According to equation (2), an implicit input measures the ability of an industry to generate profitability which is remunerated by the net operating surplus. Therefore the total output value is equal to the total cost and a balanced production account can be established (cf. table 3).

"place table 3 here"

The volume of capital consumption (equipment, software and structure) is calculated by the depreciation at constant price. The quantity of labor is estimated in full-time equivalent employee. The volumes of taxes and subsidies on production are directly linked to their related quantity output indexes. Finally, profitability is divided into a volume component, which is assumed constant over the whole period, and a price effect which therefore follows its value changes.

Productivity Surplus and TFP growth

For any of the 63 sectors PS, measured as the gap between input and output quantity variations, leads to different results in accordance with the chosen price system (Laspeyres or Paasche formulations). At the aggregate level and with Laspeyres price weights for quantities, the average annual $PS_{\text{of aggregation}}$ amounts to 141.6 billion dollars (2005 prices) while with Paasche weights, it only amounts to 133.6 billion dollars. This difference originates from fast decreasing output prices for some main industries such as computer and electronic products or price volatility due to an inelastic demand for several sectors such as oil and gas extraction or petroleum and coal products. Therefore, the Bennet formulation calculated as an arithmetic mean of the Paasche and Laspeyres indexes seems more appropriate for the evaluation of the productivity surplus. Over the whole period and at the aggregate level, its annual average is around 137.6 billion dollars (2005 prices). This amount is strictly equal to the arithmetic mean of the Laspeyres and Paasche productivity surpluses.

According to equation (11), the TFP growth rate at the aggregate level is calculated as the weighted arithmetic mean of the 63 sectoral TFP changes generated by technological and efficiency changes. Figure 2 presents TFP evolutions between 1987 and 2011 using the Bennet PS formulation. Over the whole period, the average productivity gains of the North American industries followed a trend of 0.85% resulting from the difference between output and input quantity changes of 2.71% and 1.86%, respectively.

[6] http://www.bea.gov/industry/

Indeed, TFP growth rates have been significantly different between the 63 industries over the last 24 years (cf table 4). Not surprisingly, the computer and electronic products industry had the highest level of TFP growth (8.13%) followed by the securities, commodity contracts and investments, and wholesale trade (respectively 4.09% and 2.57%). The worst performances occurred in the oil and gas extraction (-3.19%), educational services (-1.07%), management of companies and enterprises (-0.81%). Beyond these long run average trends, one can mention the more or less chaotic TFP evolutions among the different industries. In the computers and electronic products, continual innovations in technology resulted in a more robust TFP growth than in the oil and gas extraction where output opportunities are more dependent on the business cycle.

"place figure 2 here"

"place table 4 here"

Distribution of economic surplus and price advantages

Over the period from 1987 to 2011, the aggregate economic surplus of PS and all negative price advantages expressed in absolute value amounted to an annual average of 180.6 billion dollars (2005 prices). This new resource largely comes from PS (76.2%), relative price disadvantages to different stakeholders' fixed capital (7.2%), and customers (16.6%). As shown in figure 3, these resources are mainly distributed between employees (50.7%) and profitability (37.8%) while suppliers of intermediate inputs acquired less than 12%.

"place figure 3 here"

Out of this balanced surplus account established at the aggregate level, more detailed assessments can be drawn for any stakeholder from the different industries. For example, TFP trend for the automobile industry does not exceed 0.69% which denotes an annual average economic surplus of 6.7 billion dollars (2005 prices). PS represents only 44% of all resources while the suppliers provide 47% due to significant price decreases of intermediate inputs. Finally, losses incurred by firms represent 6.6% of the total while the contribution from fixed capital was 2.4 percent. Customers are the quasi exclusive beneficiaries of these resources as they received nearly 99% of the global economic surplus.

"place figure 4 here"

The story is different for the banking industry. With a very slow TFP trend of 0.21%, this sector received an economic surplus of 8.2 billion dollars. PS accounted for 29.3% of this global resource while price disadvantages for customers and fixed capital providers constituted 46% and 24.7%, respectively. These stakeholders are the losers in the distribution of productivity gains. Banks high profitability rates and remuneration to their employees accounted for nearly 62% and 36% respectively, of the economic surplus.

"place figure 5 here"

The real estate industry acquired an economic surplus of 21.6 billion dollars due productivity gains (PS =83.9%) and price disadvantages for customers (16.1%). The main beneficiaries are the firms which monopolized more than 92% of these new resources.

“place figure 6 here”

Based on equation (8), the evolution of each stakeholder’s price advantage resulting from annual TFP variations can be retrieved. It is therefore possible to analyze the distribution of productivity gain between the beneficiaries and the losers from 1987 to 2011.

Obviously, the dynamics of the distribution of TFP gains is specific to each industry according to its own productivity rate and relative price structure. In some industries, a particular stakeholder is able to increase its advantage faster than TFP gains which have therefore to be compensated by new financial resources from other stakeholders (negative price advantages).

The real estate sector illustrates this case (cf. figure 7). Until 2007, firms’ profitability increased faster than TFP gains and the gap between these two growth rates was totally compensated by the customers’ price disadvantage (increases in housing or property costs). The other stakeholders did not benefit significantly from this growing economic surplus.

“place figure 7 here”

For the banking industry, two trends can be highlighted. First, the TFP decrease over the period 1993-1998 has been totally compensated by the customers. Second, the productivity growth between 1998 and 2011 has mainly benefited banks through their higher profitability although the clients have not recovered substantial price advantages.

“place figure 8 here”

In contrast to these two services sectors, customers and suppliers of intermediate inputs have respectively been the main winners and losers in the automobile industry. During the most recent period the impact of the crisis was clearly visible between 2007-2009 while in 2010 and 2011 the Obama Administration’s recovery plan led to a rebound in productivity to its pre-crisis level.

“place figure 9 here”

At the aggregate level (cf. figure 10), the evolution of TFP gain distribution clearly reveals that employees and firms are the winners as their respective price advantage indexes are progressive over most of the period whereas customers and intermediate input suppliers are the losers. For these two latter stakeholders, one can note the quasi perfect inverse correlation between their respective indexes. Customers benefited from decreases in the real price of intermediate inputs until 2002 while suppliers benefited from increases in real prices during the more recent period from 2002-2008. Fixed capital remuneration had a slight but continuous disadvantage as a result of the decline of its depreciation cost.

“place figure 10 here”

Regarding the two main beneficiaries of TFP gains, namely employees and firms, our results do not seem to match those commonly mentioned in the current debate about the distribution of gains from productivity. According to the statistics from the Bureau of Economic Analysis, wages and salaries have grown more slowly than the GDP rate and their share has declined from 52.0% to 47.3% between 2001 and 2011. Over the same period, the corporate profits after tax have increased from 4.6% to 10.8%. This clearly establishes that the corporations took relatively more advantages of the US TFP growth than the employees. Our results illustrated by figure 8 do not confirm this conclusion as the TFP distribution changes give a slight advantage to the labor remuneration relatively to the firms' profitability (respective trends of 0.58% and 0.41% for the period 1987-2011 or 0.36% and 0.31% for the period 2001-2011).

However, methodological choices and/or statistical limitations of this study can partially explain this divergence.

First, concerning the firms' price advantage, it is noteworthy to realize that our indicator was measured through the net operating surplus of the whole economy which increased more slowly than the profits of the corporate firms (respectively 2.9% and 6.1%). In addition and contrary to the other stakeholders' price advantages, this indicator is not a pure price effect but indeed a residual profit value change.

Second, relating to the evolution of the unit labor cost, we included the whole workforce in the same stakeholder group namely, "employees" and did not distinguish the specific price advantages related to the different percentiles of income. Based on Piketty and Saez (2003) and updated by Saez (2013), the US labor market has been creating much more inequality over the recent period and the top earners benefit disproportionately from the aggregate productivity gains. According to figure 11, the decline in real terms of the household median income relatively to the mean income since 2000 confirms that a large part of American workers are not benefiting from TFP growth. It is beyond the scope of this paper to draw up a detailed list of explanations behind the triptych: -*income inequalities, distribution of productivity gains and corporate profit increases*-. Nevertheless, the erosion of labor standards, increase in globalization, high trade deficits and the decreasing rate of productive investment can be mentioned as interrelated factors which have been at the source of the redistribution from labor to profitability and the rise in salary inequality since 2000 (Mishel, Gee, 2012).

"place figure 11 here"

4. STRUCTURE OF PRICE ADVANTAGE DISTRIBUTION AND TFP CHANGES

This section attempts to study the relationship between TFP growth rates and the structure of productivity gain distribution among the main stakeholders at the industry level. More precisely, is it possible to characterize high and low productive industries by particular profiles of their specific surplus accounts? First, a simple mean-test is conducted over the whole period from 1987-2011. Second, taking advantage of the panel data structure of our series, within regression analyses are performed in order to estimate the effects of productivity gains on stakeholders' price advantages.

Characterization of stakeholders' price advantage changes through a simple mean-test

For each stakeholder, price advantage changes are compared for two groups of industries defined by their respective TFP trends estimated over the whole period. Group 1 includes the 50% less productive sectors while the other group consists of the 50% more productive industries. The associated t-tests enable us to conclude if there are significant differences in price advantages between the highest and the lowest productive sectors.

"place table 5 here"

According Table 5 it is clear that over the last 24 years, industries with higher TFP growth rates have benefited customers and firms via high price advantage or profitability rates while relative remunerations of the other inputs do not seem to be affected by productivity gaps between sectors. This result is quite intuitive and is linked to the price and cost convergence process due to the global mobility of production factors among industries. In fact, price changes for these inputs depend first on their specific market structure and their own endowments defined at the macroeconomic level. Therefore TFP gains generated within a particular sector must not considerably influence their global market prices. However, they should impact significantly final demand prices and profitability rates of the considered industry.

Estimation of a relationship between stakeholders' price advantages and TFP growth rate through a panel data procedure

Taking advantage of the panel structure of our data (63 industries over the period 1987-2011), a regression analysis can be conducted between price advantage rates and TFP changes. The temporal and spatial dimensions of the sample allow us to simultaneously take into account the business cycle and the sectoral characteristics of the American economy. The following regressions are therefore estimated for price advantages related to customers, inputs, and profitability, respectively:

$$\left(\frac{-dpy}{py}\right)_{n,t} = \alpha^0_n + \gamma^o_t + \theta^o \left(\frac{dTFP}{TFP}\right)_{n,t} + \mu^o{}_{n,t} \text{ for the customers}$$

$$\left(\frac{dw_i x_i}{py}\right)_{n,t} = \alpha^i_n + \gamma^i_t + \theta^i \left(\frac{dTFP}{TFP}\right)_{n,t} + \mu^i{}_{n,t} \text{ for any input i}$$

(i = intermediate inputs, employees, fixed capital, profitability) (13)

n = sector index, t = time index

with $\mu_{n,t}$ = the usual random error component

Following equation (8) one can notice that $\theta^o + \sum_1^{I+1} \theta^i$ must be equal to 1 as the total TFP gains have to be shared among the different stakeholders. Consequently, estimates from the seemingly unrelated regression equations (13) explain the impact of TFP changes on evolution of the structure of stakeholder's remuneration. [7] Results from table 6 are in line with those established in table 5. Changes in TFP have significant impacts on final demand prices for customers and profitability rates for firms. Fifty-one percent and 47% of the benefits of TFP changes accrue to customers and firms' profitability respectively while employees obtain less than 6%. Finally, price advantages accruing to fixed capital and intermediate input suppliers are not or negatively correlated to these TFP gains.

"place table 6 here"

7 Seemingly unrelated regression estimates are obtained by first estimating the set of equations (13) with cross-equation constraints imposed, but with a diagonal covariance matrix of the disturbances across equations. These parameter estimates are used to form a consistent estimate of the covariance matrix of the disturbances, which is then used as a weighting matrix when the model is reestimated to obtain new values of the parameters. These estimates are consistent and asymptotically normal, and under some conditions, asymptotically more efficient than the single equation estimates (Hall, Cummins, 2005)

5. CONCLUSION

Several conclusions can be drawn from this study concerning the generation and distribution of productivity gains in American industries over the last 24 years.

From a methodological point of view, our results first argue in favor of using equicharateristic price or quantity indexes such as Bennet indicators in order to estimate TFP evolutions. Indeed, if industries are characterized by a high negative correlation between prices and output quantities through an inelastic demand (such as agriculture, oil and gas extraction or coal and petroleum products), these indicators seem more appropriate than the usual Laspeyres or Paasche approaches. Second, they demonstrate the usefulness of the surplus accounting technique and its additive formulation in order to calculate simultaneously the generation and distribution of aggregate productivity gains based on 63 individual sectors. Moreover, this framework can easily be applied to any sectoral component of the whole economy with the aim of addressing the key issue of stakeholder remunerations in relation (or not) to their own productivity gains and market powers.

From an empirical point of view, our study clearly supports the fact that over the last 24 years, the American economy has continuously benefited employees and companies in the distribution of productivity gains due to increasing average real wages and profitability rates. Comparatively, customers, suppliers of intermediate inputs and providers of fixed capital have not received substantial benefits. However for the last 12 years, it is crucial to state that the price advantage for employees has been essentially captured by the top earners while the median income has decreased significantly. Actually, most of American workers have not benefited from productivity gains during the last decade.

Beyond these synthetic results established at the aggregate level, there are differences among industries. For instance the automobile industry has mostly favored customers at the expense of subcontractors while the banking and real estate sectors have essentially distributed their economic surplus to their own companies through high levels of profitability.

Finally at the sectoral level, industries characterized by high TFP rates are able to transmit their productivity surplus to customers and companies but not to the other stakeholders while industries with low or negative TFP changes clearly hurt customers through significant output price increases. As a final point, concerning employees of any particular industry, their price advantages are mainly driven by interrelated factors and TFP growth produced at the macroeconomic level and not by the ones generated within the individual sectors.

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Table 1: Balanced surplus account

Uses	Resources
  $-dp_j y_j^t$ for any price decrease of output *j* + $dw_i x_i^t$ for any price increase of input *i* …	PS (if >0) + $dp_j y_j^t$ for any price increase of output *j* + $-dw_i x_i^t$ for any price decrease of input *i* …
Total economic surplus	Total economic surplus

Table 2: Origin and distribution of the total economic surplus

	Total economic surplus	
	Distribution or uses	Origin or resources
Technological and Efficiency changes	Negative productivity surplus	Positive productivity surplus
Customers	Decrease in output prices	Increase in output prices
Suppliers of intermediate inputs	Increase in the price of intermediate inputs	Decrease in the price of intermediate inputs
Employees	Increase in the wage rates	Decrease in the wage rates
Equipment and structure: fixed assets	Increase of depreciation cost	Decrease of depreciation cost
Firms	Increase in the operating surplus rate	Decrease in the operating surplus rate

Table 3: Inputs and outputs retained in the surplus decomposition

Inputs	Outputs
Intermediate inputs: + Labor + Equipment & Software depreciation + Structure depreciation + Operating surplus	Gross output - Taxes on production + Subsidies on production
Total cost	Total revenue

Table 4: American industries classified according to their respective TFP growth rates
(Trends estimated on the period 1987-2011)

Industries	TFP growth	Industries	TFP growth	Industries	TFP growth
Computer and electronic products	8.13%	Funds, trusts, and other financial vehicles	0.97%	Legal services	0.34%
Securities, commodity contracts, and investments	4.09%	Textile mills and textile product mills	0.75%	Fabricated metal products	0.30%
Wholesale trade	2.57%	Plastics and rubber products	0.75%	Insurance carriers and related activities	0.29%
Broadcasting and telecommunications	1.98%	Forestry, fishing, and related activities	0.71%	Federal	0.26%
Miscellaneous manufacturing	1.78%	Motor vehicles, bodies and trailers, and parts	0.69%	Printing and related support activities	0.26%
Retail trade	1.67%	Accommodation	0.66%	Nonmetallic mineral products	0.23%
Publishing industries (includes software)	1.64%	Transit and ground passenger transportation	0.65%	Federal Reserve banks, credit intermediation, and related activities	0.21%
Air transportation	1.62%	Waste management and remediation services	0.64%	Food and beverage and tobacco products	0.19%
Water transportation	1.47%	Pipeline transportation	0.58%	Wood products	0.06%
Warehousing and storage	1.43%	Motion picture and sound recording industries	0.56%	Other transportation equipment	-0.05%
Computer systems design and related services	1.34%	Utilities	0.54%	Paper products	-0.12%
Real estate	1.30%	Furniture and related products	0.51%	State and local	-0.12%
Farms	1.29%	Chemical products	0.47%	Amusements, gambling, and recreation industries	-0.17%
Administrative and support services	1.25%	Electrical equipment, appliances, and components	0.41%	Ambulatory health care services	-0.17%
Petroleum and coal products	1.22%	Other transportation and support activities	0.40%	Information and data processing services	-0.32%
Performing arts, spectator sports, museums, and related activities	1.18%	Social assistance	0.37%	Other services, except government	-0.33%
Truck transportation	1.11%	Machinery	0.35%	Hospitals and nursing and residential care facilities	-0.54%
Miscellaneous professional, scientific, and technical services	1.11%	Food services and drinking places	0.35%	Construction	-0.57%
Mining, except oil and gas	1.08%	Support activities for mining	0.34%	Management of companies and enterprises	-0.81%
Apparel and leather and allied products	1.04%	Primary metals	0.34%	Educational services	-1.07%
Rail transportation	1.00%			Oil and gas extraction	-3.19%
Rental and leasing services and lessors of intangible assets	0.99%				

Table 5: Mean tests for price advantage rates between industries with low and high TFP growth

	LTFP	*HTFP*	*t-test*
Customers	-0.85%	0.37%	-2.76
Intermediate input suppliers	0.16%	0.14%	0.06
Employees	0.50%	0.49%	0.07
Fixed capital	-0.04%	-0.11%	1.37
Profitability	0.26%	0.59%	-2.63

Table 6 SUR regression between price advantages and TFP changes (including fixed sector and time effects)

	$\hat{\theta}$	t-stat	R^2
Customers	0.5088	17.3262	0.3154
Intermediate input suppliers	-0.0329	-1.99227	0.2807
Employees	0.0544	7.1807	0.2182
Profitability	0.4712	23.3410	0.2994
Fixed capital*	-0.0014	-0.5993	0.1418

* One equation has to be omitted in the SUR procedure in order to avoid a perfect singularity of the data. The choice of the omitted equation does not affect the parameter estimates.

Figure 1: Illustration of the decomposition of the Bennet index

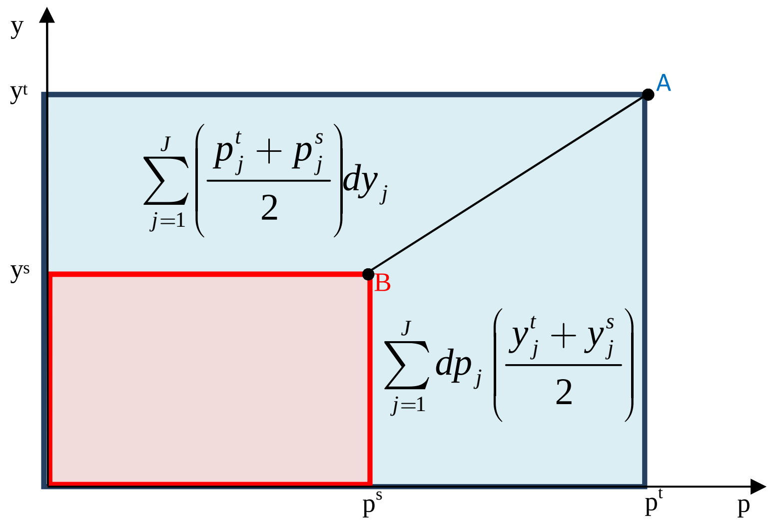

Figure 2: TFP evolutions over the period 1987-2011(in logarithm terms, 1 = 1987)

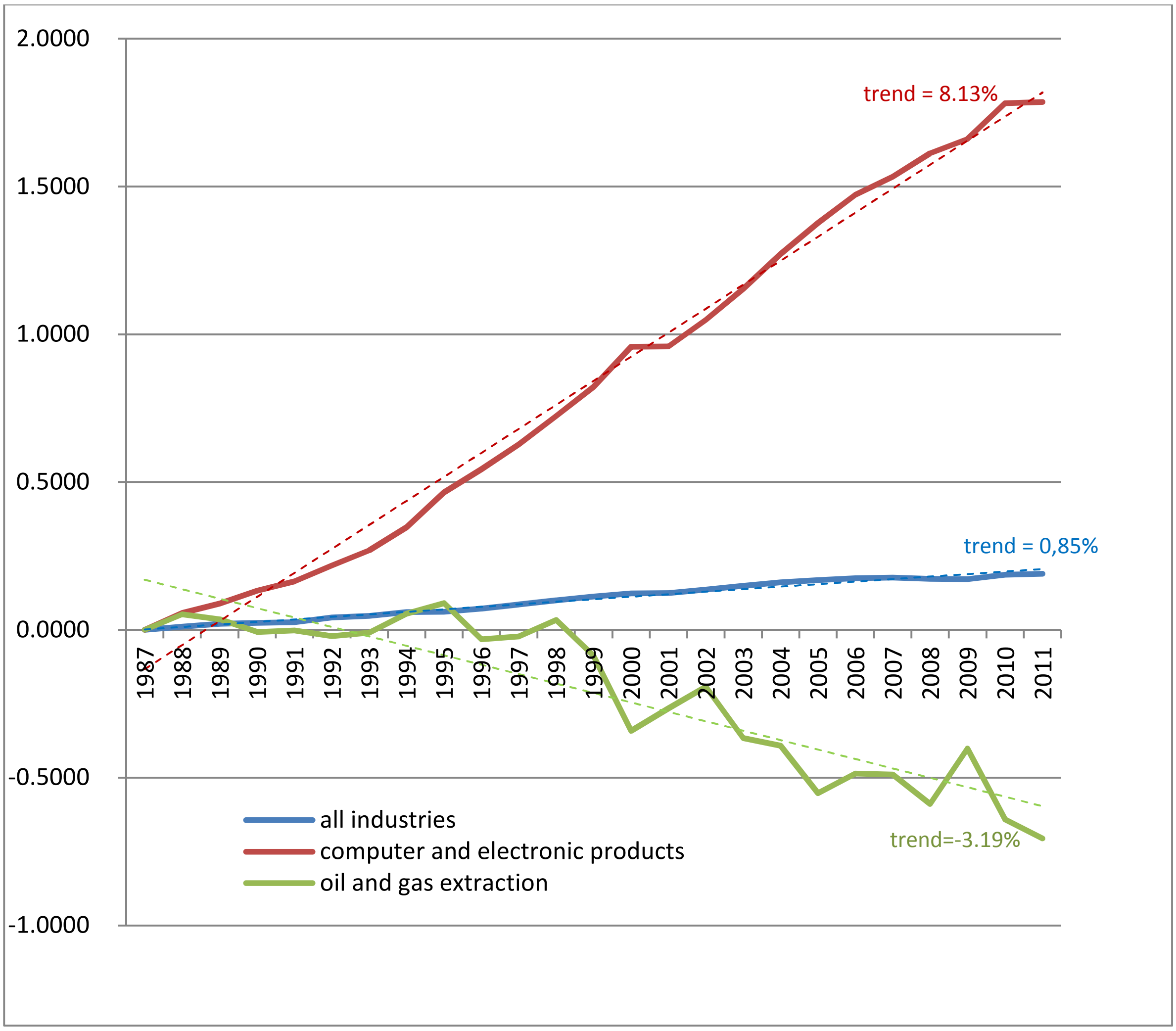

Figure 3: Average annual balanced surplus account in percentages for all industries

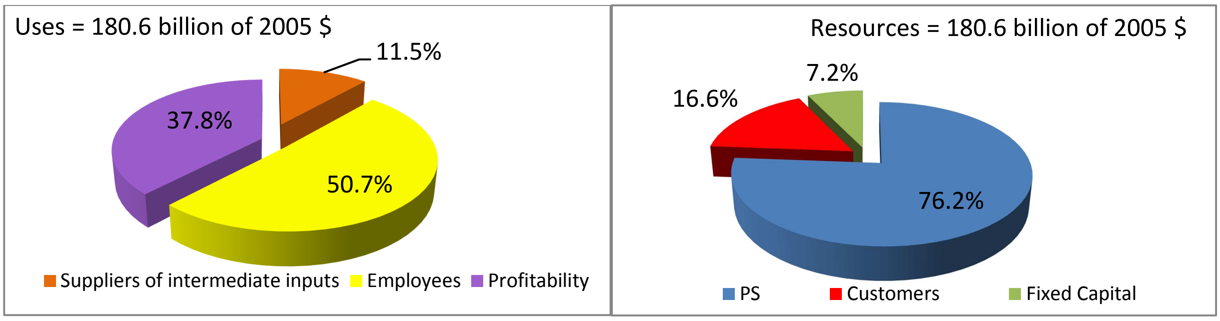

Figure 4: Average annual balanced surplus account in percentages for the automobile industry

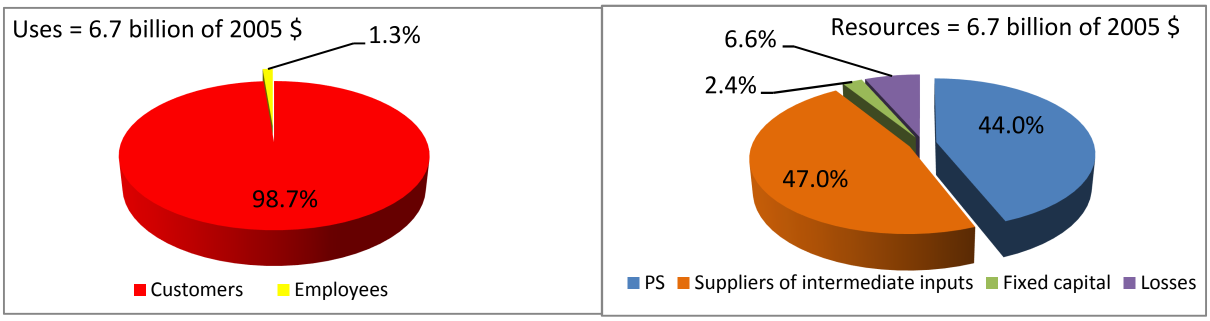

Figure 5: Average annual balanced surplus account in percentages for banking industry

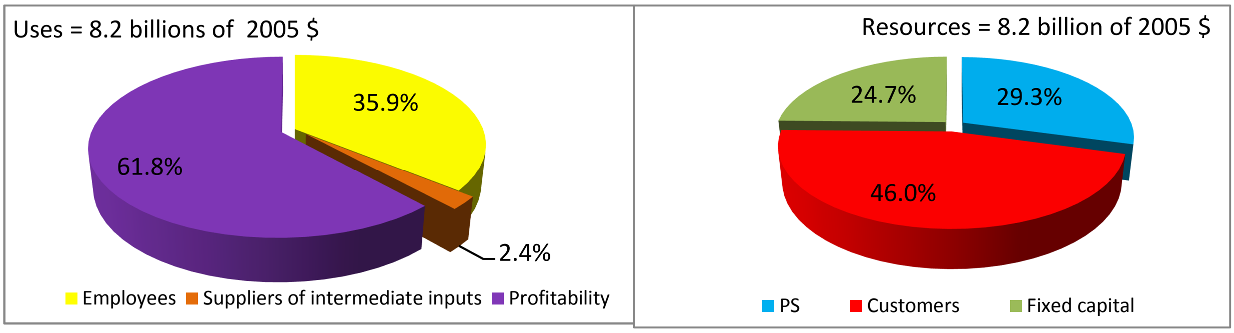

Figure 6: Average annual balanced surplus account in percentages for real estate industry

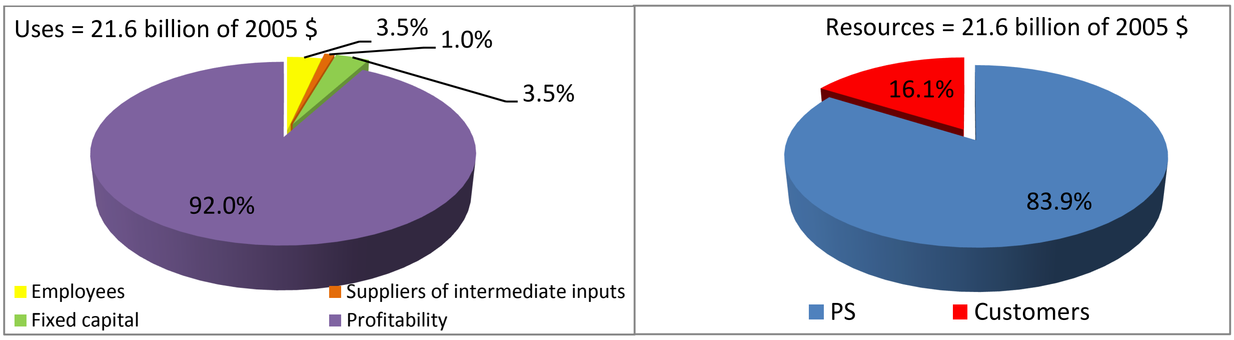

Figure 7: TFP and Price Advantages indexes (in logarithm terms) for real estate industry

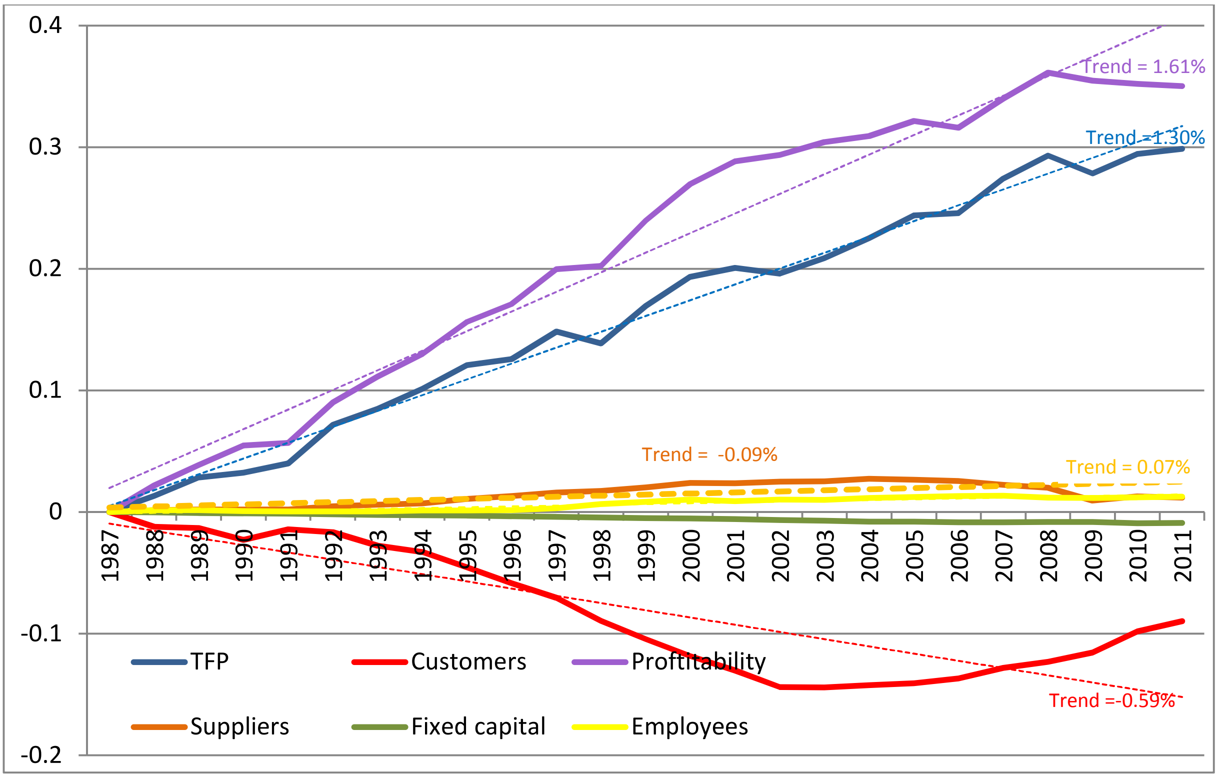

Figure 8: TFP and Price Advantages indexes (in logarithm terms) for banking industry

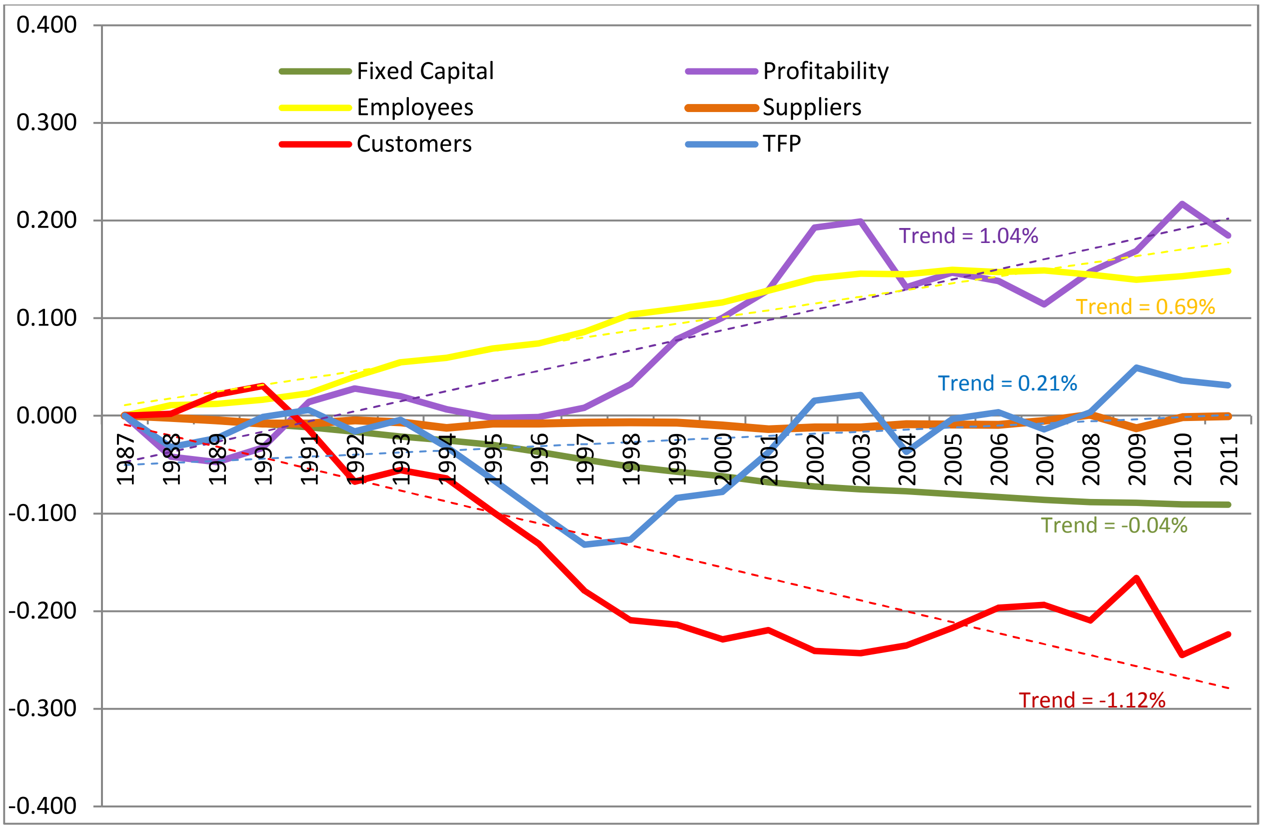

Figure 9: TFP and Price Advantages indexes (in logarithm terms) for automobile industry

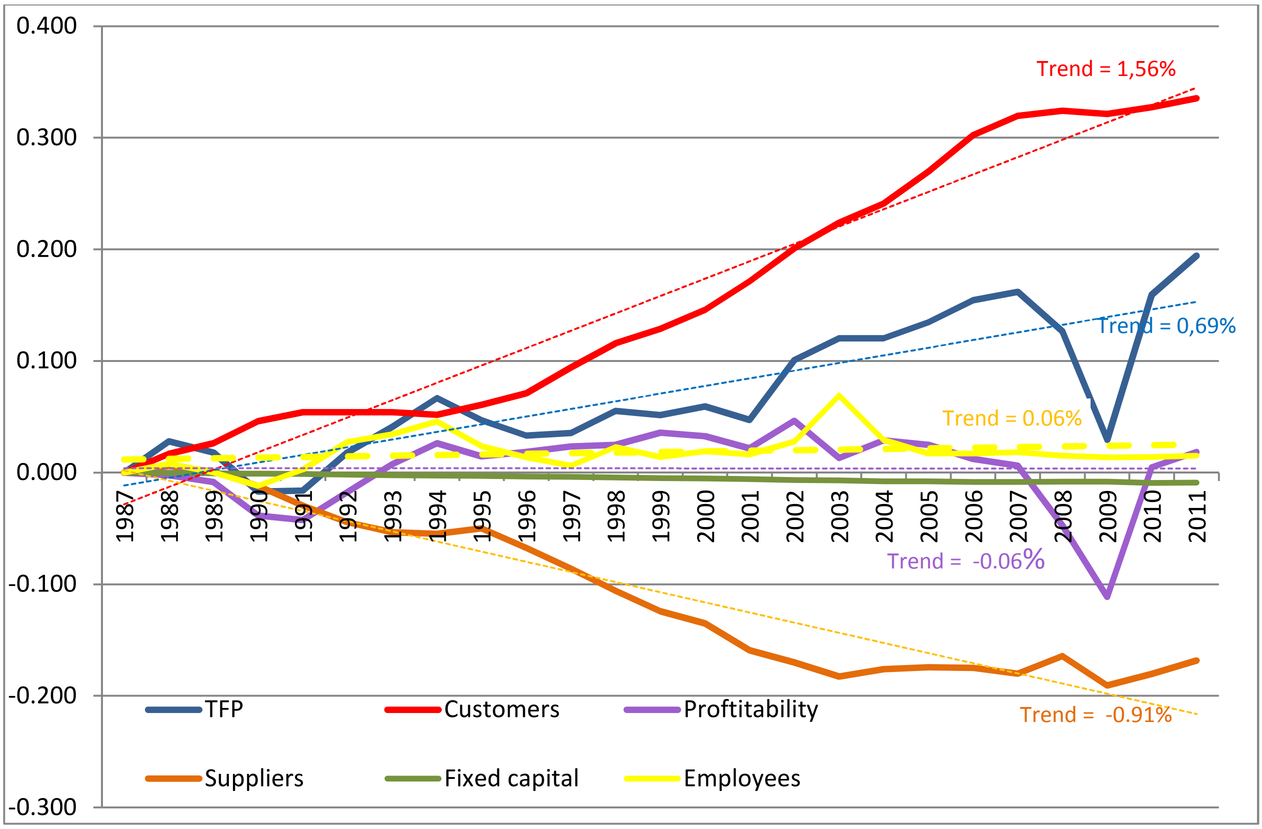

Figure 10: TFP and Price Advantages indexes (in logarithm terms) for all industries

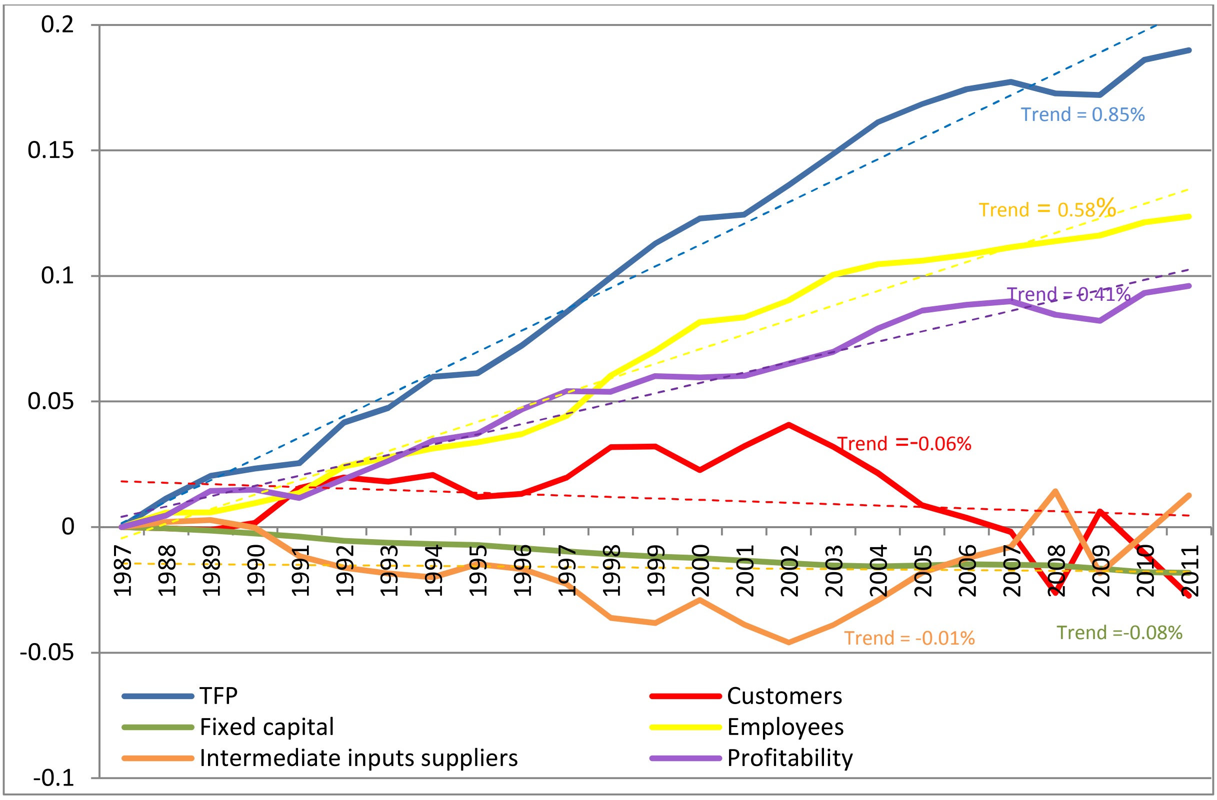

Figure 11: Real Wages and Salaries per Full Time Equivalent Employee compared to Real Household Income Median (in 2005 $)