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# MEASURING THE DEGREE OF COLLUSIVE CONDUCT IN THE MEXICAN MANUFACTURING SECTOR

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MEASURING THE DEGREE OF COLLUSIVE CONDUCT IN THE MEXICAN MANUFACTURING SECTOR[1]

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ABSTRACT

The paper estimates the degree of collusive conduct in the mexican manufacturing industries by estimating the degree of market power of a representative firm in an industry. Similarly to Hall (1988), the identification assumption for the degree of market power is that total factor productivity growth is not procyclical. To measure the degree of collusive conduct, the paper estimates the market elasticity of demand by exploiting a covariance restriction between demand shocks and productivity shocks (Shapiro (1987)). The degree of collusive conduct is obtained by calculating the ratio between the representative firm´s elasticity of demand and the market elasticity of demand.

[1] Preliminary.

## INTRODUCTION

Current research for the mexican economy estimates market power by calculating concentration indexes (Casar "La Organizacíón Industrial en México). If Cournot competition is present, the Herfindahl concentration index gives us a measurement of the deadweight losses in case we know the market elasticity of demand.

Several papers have shown that concentration indexes may not coincide with econometric results[2]. Further, repeated games models predict that any equilibrium between full collusion and perfect competition may result when repeated interaction is present. Thus, concentration indexes do not reflect all the possibilities predicted by economic theory.

This paper applies econometric techniques to measure market conduct. We use refutable implications with respect to perfect competition to estimate the markup. This estimate furnishes us with a measurement of the degree of elasticity of demand that a representative firm faces. Furthermore, exploiting a covariance restriction between productivity shocks and demand shocks, the paper estimates the market elasticity of demand. The ratio of the two measurements gives us an estimate of the degree of collusiveness that exists in mexican manufacturing sectors. Bresnahan (1989) argues that this estimate is a measure of conduct for models where Cournot behavior is not present.

The methodology uses Hall´s identification assumption that states that productivity is not intrinsically procyclical. Thus, the finding of a procyclical productivity is an implication of market power. To estimate the market elasticity of demand, the paper uses Shapiro proposal. According to him, the residual calculated after estimating the markup, using Hall´s methodology, should be a good instrument for estimation of the market elasticity of demand. The reason behind this idea argues that productivity shocks should not be correlated with taste shocks.

Castañeda (1996 (a)) estimates the markup for 49 manufacturing sectors. In this paper we extend the analysis and estimate the market elasticity of demand. This estimate, together with the markup estimate, furnishes us with a measure of market conduct that may differ from the predictions of the markup estimate.

## METHODOLOGY

Let us assume a constant returns to scale technology with no intermediate inputs[3]:

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[2]See the work by Domowitz, Hubbard y Petersen (1988).

[3] We do not have data on intermediate inputs.

$$O(t)=A(t)K(t)f\left(\frac{L(t)}{K(t)}\right) \tag{1}$$

$A(t)$ represents Hicks neutral technical progress, $K(t)$ is the stock of capital, $L(t)$ represents labor input and $O(t)$ is output. Differentiating the last equation with respect to time and assuming that marginal product is equal to real wage:

$$\frac{\left(\frac{d\frac{O(t)}{K(t)}}{dt}\right)}{\left(\frac{O(t)}{K(t)}\right)}=\frac{\dot{A}(t)}{A(t)}+\alpha(t)\frac{\left(\frac{d\frac{L(t)}{K(t)}}{dt}\right)}{\left(\frac{L(t)}{K(t)}\right)} \tag{2}$$

$\alpha(t)$ equals the share of labor income in nominal output.

Under perfect competition, the above equation can be used to measure the rate of change of technical progress, $\frac{\dot{A}(t)}{A(t)}$, (Solow´s residual). If perfect competition is not present, then we may have a markup over marginal cost. Under this condition, the measurement of technical progress given by equation (2) will not be accurate.

Define $c$ and $p$ as marginal cost and price. Under perfect competition price equals marginal cost, $p=c$. Define $\alpha*$ as labor´s share in output whenever output is being calculated at marginal cost, $\alpha*=\frac{wL}{cO}$. If perfect competition is present, $\alpha=\alpha*$. Under imperfect competition, there is a markup over marginal cost, $\beta=\frac{p}{c}$, Solow´s residual could be calculated if labor´s share in output valued at marginal cost $(\alpha*)$ replaces $\alpha$ in equation (2).

$$\frac{\left(\frac{d\frac{O(t)}{K(t)}}{dt}\right)}{\left(\frac{O(t)}{K(t)}\right)}=\frac{\dot{A}(t)}{A(t)}+\alpha*(t)\frac{\left(\frac{d\frac{L(t)}{K(t)}}{dt}\right)}{\left(\frac{L(t)}{K(t)}\right)} \tag{3}$$

Notice that $\alpha*=\beta\alpha$ . The problem with implementing equation (3) is that we do not know what is the level of the markup. Solow assumes that $\beta=1$ . Hall, instead, uses the last equation to estimate the markup, $\beta$ , by assuming that the Solow´s residual in level follows a random walk with drift and that $\beta$ was a constant that could be estimated. Thus, Hall assumes that $\frac{\dot{A}(t)}{A(t)}=\bar{A}+\omega$ ,

(5)

with $\bar{A}$ representing the average rate of growth, and $\omega$ a stochastic error not correlated with business cycles. Then he estimates $\beta$ by using an instrument that was correlated with the business cycles and tested for the hypothesis $\beta=1$ . Hall estimates the following equation by using an instrument correlated with the business cycles:

$$\frac{\left(\frac{d\frac{O(t)}{K(t)}}{dt}\right)}{\left(\frac{O(t)}{K(t)}\right)}=\bar{A}+\alpha\beta\frac{\left(\frac{d\frac{L(t)}{K(t)}}{dt}\right)}{\left(\frac{L(t)}{K(t)}\right)}+\omega \tag{4}$$

As Bresnahan and Shapiro have suggested, the markup is not the right metric to measure the degree of collusiveness in an industry. A monopoly with an inelastic market demand will have a higher markup than a monopoly with an elastic market demand. Thus, the right metric to test for collusiveness should consider the market elasticity of demand. The estimate obtained from Hall´s methodology can give us the elasticity of demand faced by a representative firm. Also, using the plausible assumption that productivity shocks are not correlated with taste shocks, we can estimate the market elasticity of demand. The ratio of the market´s elasticity of demand to the firm´s elasticity of demand can be used to calculate the degree of collusive behavior in the industry.

Define $\epsilon'$ as the representative firm´s elasticity of demand and define $\epsilon$ as the market elasticity of demand. The ratio, $k=\frac{\epsilon}{\epsilon'}$, is the conduct parameter that measures the degree of collusiveness in an industry. Under full monopoly $k=1$, under perfect competition it equals zero.

To overcome the simultaneity problem present in the estimate of the demand equation, this paper uses the residual obtained from equation (4) as an instrument for the demand equation. The paper estimates the following homogeneous demand system:

$$\frac{dO(t)}{dt}-\frac{dY(t)}{dt}=\epsilon\frac{dRP(t)}{dt}+u(t) \qquad (5)$$

Where $\frac{dO(t)}{dt}$ is the rate of growth of sectoral output, $\frac{dY(t)}{dt}$ is the rate of growth of aggregate output, $\frac{dRP(t)}{dt}$ is the rate of growth of relative price and $u(t)$ is the demand shock[4].

RESULTS

Equations (4) and (5) are estimated for the mexican manufacturing sector. The parameter $k$ is calculated with the results of both equations[5]. Estimates are shown for individual industries and for pooled industries. Other methodologies that use accounting data can be used to estimate $k$ for individual firms (see Bresnahan (1989)). This paper estimates $k$ from industry data. We use data from "Cuentas Nacionales" published by INEGI and from "Acervos de

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[4]We estimated also a nonhomogeneous system by putting the rate of growth of aggregate output on the right hand side of the demand equation and estimating its coefficient. The results did not vary significantly from those reported.

[5]From the estimate of $\beta$ we calculate the representative´s firm elasticity of demand $\epsilon'$. The standard errors are calculated from first-order Taylor series approximation.

Capital" published by Banco de México. The time span of the series goes from 1970 to 1991. As far as we are aware, this is the first study that estimates the parameter $k$ for the Mexican manufacturing sectors. Results for pooled industries are shown in Table 1[6]. The pooling procedure is as follows: Equation (4) is estimated for each sectoral panel of industries, allowing for the markup to vary across each industry in the panel. The instruments used are the current rate of growth of GDP and the lagged value of this variable[7]. The residuals from this estimate are used to estimate the demand equation (5)[8]. In the panel for equation (5), each industry has a different intercept but a common slope. Equation (4) is estimated by allowing each industry to have a different intercept and a common markup (slope). The parameter $k$ for the panel is obtained by using the results from equation (4) with a common markup and the results from equation (5) with a common slope. Except for the markup in food and beverages and the markup in wood, for all sectors listed in Table 1, standard tests do not reject the hypothesis that the slopes of each industry within the panel are equal, thus justifying the use of the pooling technique. The Durbin-Watson statistics are the average of the two digit industries included in the panel.

The first two columns gives us the estimates of equation (4), the first column gives us the markup, the next column gives us the Durbin-Watson statistic calculated as explained above. The number in parentheses are the standard errors of the coefficient estimates. Except for paper, all sectors show a markup that rejects the hypothesis of price equal to marginal cost. The third column gives us the implied representative firm´s elasticiy of demand. The fourth column gives us the market elasticity of demand and the fifth column gives us the measure of monopoly power ( $k$ ). All estimates of the market elasticity are negative. In food and beverages, machinery and equipment, chemicals, textiles and metal products, the market elasticity is significantly different from zero. The pooling technique allows us to have precise estimates in most of the sectors shown in the Table.

The measure of monopoly power gives us different results with

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[6]See the appendix, for the definition of industries pooled under a single sector.

[7]Castañeda (1996 (a)) discusses the reasons for using these two instruments.

[8] With this procedure, we are assured that the instrument is orthogonal to the taste shock in the sample.

regard to market power than those given by the markup alone. We reject the hypothesis of a markup equal to one in Glass and Cement, but this sector has a market elasticity that is essentially zero. Thus, the parameter $k$ rejects the hypothesis of full monopoly ( $k$=1 ) and cannot reject the hypothesis of perfect competition. With textiles we also have differing results with respect to the information provided by the markup and the information provided by the conduct parameter. With respect to the markup, there is market power in textiles. In contrast, when we look at the parameter $k$ , we cannot reject the hypothesis of perfect competition and we can reject the hypothesis of full monopoly. In other sectors, the inference from the markup coincides with the inference obtained from the conduct parameter, such is the case for food and beverages, machinery and equipment, chemicals and metal products. We could argue that there is oligopolistic behavior in these industries. In wood, basic metals, paper and transport equipment, the estimates of conduct are too imprecise to yield any inference.

Notice that food and beverages, machinery and equipment, textile and metal products have similar markups. However, the conduct parameter yields different inferences. In textiles we cannot reject the hypothesis of perfect competition, whereas in the others we can. In machinery and equipment and metal products we cannot reject the hypothesis of full collusion, whereas in food and beverages and textiles we can. Thus, sectors with similar markups yield different inferences with regard to market conduct. The sole information on markup is poor if we want to have any measure of market conduct. Similarly, chemicals has a lower markup than textiles. However, for chemicals, the market conduct parameter does reject the hypothesis of perfect competition.

Previous work, using single two digit estimates of the markup, has shown that there is ample evidence of market power in the mexican manufacturing sector. The panel results on the parameter $k$ suggest that 26 sectors show evidence of non-competitive conduct[9]

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[9]Previous work, using evidence of the markup and making single two digit estimates, showed evidence of noncompetitive conduct in 30 industries (see Castañeda 1996(b)). The panel results on the markup in this work, reject the perfect competition hypothesis in 44 industries (this number is equal to the two digit industries included in the following sectors: food and beverages, wood, machinery and equipment, basic metals, glass and cement, chemicals, textiles, metal products and transport equipment).

[10].

## Table 1: Pooled Industries

| INDUSTRY | MARKUP | DW | ϵ´ | ϵ | DW | *k* |
|---|---|---|---|---|---|---|
| FOOD AND BEVERAGES | 2.6* (.44) | 1.99 | -1.61~ (.16) | -.536^ (.144) | 1.99 | .333°+ (.09) |
| WOOD | 3.4* (.67) | 1.72 | -1.42~ (.121) | 1.038 (2.31) | 2.01 | .073 (1.62) |
| MACHINERY AND EQUIPMENT | 2.9* (.342) | 1.82 | -1.53~ (.095) | -1.12^ (.387) | 1.73 | .734° (.258) |
| BASIC METALS | 4.5* (1.06) | 1.94 | -1.28~ (.085) | -1.31 (1.3) | 1.54 | 1.02 (1.01) |
| GLASS AND CEMENT | 3.1* (.536) | 1.39 | -1.48~ (.123) | -.073 (.58) | 1.86 | .049+ (.392) |
| CHEMICALS | 1.6* (.367) | 2.11 | -2.6~ (.939) | -.447^ (.194) | 1.97 | .172°+ (.097) |
| PAPER | 1.9 (.597) | 1.82 | -2.04~ (.648) | -3.18 (4.69) | 1.70 | 1.55 (2.35) |
| TEXTILES | 2.6* (.672) | 2.65 | -1.63~ (.264) | -.771^ (.447) | 1.93 | .474+ (.286) |
| METAL PRODUCTS | 2.5* (.68) | 1.84 | -1.69~ (.321) | -1.16^ (.312) | 1.77 | .686° (.226) |
| TRANSPORT EQUIPMENT | 2.4* (.51) | 2.05 | -1.71~ (.262) | -1.24 (3.25) | 1.64 | .72 (1.9) |

* Rejects the hypothesis that the markup is equal to one at the five percent level.
~ Rejects the hypothesis that the firm´s elasticity is equal to zero at the five percent.
^ Rejects the hypothesis that the market elasticity is equal to zero at the five percent.
° Rejects the hypothesis of perfect competition (k=0) at the five percent.
+ Rejects the hypothesis of monopoly (k=1) at the five percent.

[10]According to the results: food and beverages, machinery and equipment, chemicals and metal products reject the hypothesis of perfect competition when using the parameter k. Altogether these panels include 26 two-digit manufacturing industries.

We also have estimates for durable and nondurable goods and for the whole manufacturing sector. The method of estimation is the same as the one used for Table 1. The results are shown in Table 2. We can see in Table 2 that the use of the pooling technique allows us to have very precise estimates of the markup, the market elasticity of demand and the conduct parameter. For durables we cannot reject the hypothesis of a common markup and a common elasticity across industries. For nondurables and manufacturing, we reject the hypothesis of a common markup across industries and we cannot reject the hypothesis of a common elasticity.

Table 2: Aggregate Pooled Industries

| INDUSTRY | MARKUP | DW | $\epsilon'$ | $\epsilon$ | DW | $k$ |
|---|---|---|---|---|---|---|
| NONDURABLES | 2.46* | 2.02 | -1.68~ | -.25^ | 1.97 | .149°+ |
| | (.30) | | (.142) | (.107) | | (.065) |
| DURABLES | 2.74* | 1.85 | -1.57~ | -1.02^ | 1.68 | .65° |
| | (.22) | | (.07) | (.36) | | (.23) |
| MANUFACTURING | 2.53* | 1.93 | -1.65~ | -.42^ | 1.77 | .25°+ |
| | (.20) | | (.083) | (.1) | | (.05) |

* Rejects the hypothesis that the markup is equal to one at the five percent level.
~ Rejects the hypothesis that the firm's elasticity is equal to zero at the five percent.
^ Rejects the hypothesis that the market elasticity is equal to zero at the five percent.
° Rejects the hypothesis of perfect competition (k=0) at the five percent.
\+ Rejects the hypothesis of monopoly (k=1) at the five percent.

As the last table shows, both the markup and the conduct parameter show that oligopolistic behavior is present at the aggregate level in the manufacturing sector. For durables we cannot reject the hypothesis of full collusion[11].
Despite of the fact that durables has a similar markup to nondurables, the market conduct parameter cannot reject the hypothesis of full monopoly for the durables industry. Thus, showing that the markup is not a good predictor of market conduct.

We also realized estimates at the two digit level. The methodology for this estimate was simple. First we estimate equation (4) for each two digit industry. The instruments used are the same as those used above. The residuals from this estimate are used to estimate the demand equation (5). The parameter $k$ is calculated by using the results from equations (4) and (5). The results are reported in Table 3. The columns have the same order and represent the same items reported in Tables 1 and 2.

[11] However, the last inference must be taken with care, we must remember that economic theory suggests that the pricing rule for durable goods entails intertemporal aspects not considered in the equations estimated.

Table 3: Two Digit Industries

| INDUSTRY | MARKUP | DW | ϵ´ | ϵ | DW | $k$ |
|---|---|---|---|---|---|---|
| 11 Meat and Dairy | 1.85 | 1.62 | -2.18 | .94 | 1.83 | -.43+ |
| | (1.52) | | (2.11) | (.96) | | (.61) |
| 13 Wheat Grinding | 2.12* | 1.92 | -1.89~ | -.32 | 1.57 | .17+ |
| | (.31) | | (.24) | (.3) | | (.16) |
| 14 Corn Grinding | 8.15* | 1.4 | -1.14~ | -.48 | 1.4 | .42+ |
| | (1.96) | | (.04) | (.38) | | (.33) |
| 16 Sugar | 5.6 | 1.23 | -1.22~ | -.17 | 1.86 | .14+ |
| | (3.92) | | (.19) | (.39) | | (.32) |
| 21 Beer | 3.6* | 1.62 | -1.38~ | -.62^ | 1.59 | .45°+ |
| | (.53) | | (.077) | (.19) | | (.13) |
| 38 Pharmaceutical Pro. | 2.3 | 2.7 | -1.8~ | -.12 | 1.4 | .07+ |
| | (1.4) | | (.79) | (.29) | | (.17) |
| 49 Fabricated Metals | 2.3 | 1.5 | -1.8~ | -.73^ | 2.1 | .41+ |
| | (1.5) | | (.89) | (.41) | | (.31) |
| 50 Other Metal Products | 3.6* | 1.4 | -1.4~ | -.36 | 1.4 | .26+ |
| | (.62) | | (.09) | (.34) | | (.24) |
| 52 Electrical Machinery | 2.8* | 1.8 | -1.5~ | (-1.4) | 1.9 | .93° |
| | (.48) | | (.14) | (.60) | | (.4) |

* Rejects the hypothesis that the markup is equal to one at the five percent level.
~ Rejects the hypothesis that the firm´s elasticity is equal to zero at the five percent level.
^ Rejects the hypothesis that the market elasticity is equal to zero at the five percent level.
° Rejects the hypothesis of perfect competition (k=0) at the five percent level.
+ Rejects the hypothesis of monopoly (k=1) at the five percent level.

We only show the results for which the market conduct parameter yields definitive inferences. The results show that the two alternative measures of market power (the markup and the market conduct parameter) do not always yield the same results. Except for meat and dairy, the market elasticity of demand is negative for all two-digit industries listed in Table 3. For industries 11, 16, 38, and 49 (Meat and Dairy, Sugar, Pharmaceutical Products and Fabricated Metals), we do not reject the hypothesis of perfect competition according to the markup standard. The collusion parameter does not reject the hypothesis of perfect competition either, but rejects the hypothesis of full collusion ( $k$=1 ). For industries 13, 14, and 50 (Wheat Grinding, Corn Grinding and Other Metal Products), the markup standard rejects the hypothesis of perfect competition, however, the collusion standard does not reject the hypothesis of perfect competition but does reject the hypothesis of full collusion. For industries 21 and 52 (Beer and Non-electrical Machinery), the markup and the collusion parameters reject the hypothesis of perfect competition. For industry 21 we are able to reject the hypothesis of full collusion too, thus showing the existence of oligopolistic competition. For industry 52 we are not able to reject the hypothesis of full collusion. For other industries, the standard deviation of the estimates (the markup or the market elasticity of demand or both) become too large and does not allow us to reject any of the hypothesis (anything can happen). For this reason we do not report the results for those industries in Table 3.

Notice that industries with similar markups yield differing predictions with regard to market conduct. Industries 21 and 50 (Beer and Other Metal Products) have the same measurement of markup (3.6). However, the market conduct predicts oligopolistic interaction for Beer and cannot reject the perfectly competitive outcome for Other Metal Products. The same inconsistency can be found in industries 13 and 52 (Wheat Grinding and Electrical Machinery). Despite of the fact that their markup does not differ very much, the market conduct parameter yields differing inferences. We cannot reject the hypothesis of perfect competition for Wheat Grinding. In contrast, we reject the hypothesis of perfect competition for Electrical Machinery.

## CONCLUDING REMARKS

In this paper we estimate market conduct as defined in Bresnahan (1989). The estimate procedure combines Hall´s identification assumption that states that the Solow residual should not be correlated with aggregate fluctuations with the assumption that productivity shocks should not be correlated with taste shocks. Using this procedure, the paper estimates the market elasticity of demand. With the information provided from Hall´s markup equation and the market demand equation, the paper calculates the conduct parameter.

The results show that the inferences obtained by estimating only the markup equation are not confirmed when we use the information provided by the conduct parameter. Thus, in searching for empirical evidence that shows the presence of market power, the researcher should have some degree of skepticism whenever the information on market power is based only on the degree of markup. More information on the market elasticity of demand is needed, to have a more precise inference on market power. Industries with similar markups yield differing inferences with regard to market conduct, whenever we use information on the market elasticity of demand.

Other studies that estimated the markup, have concluded that there is ample evidence of market power in the mexican manufacturing sector (Castañeda (1996 (a)). This study goes further in the agenda for research by estimating the market conduct parameter.

The panel results of this paper show that the parameter $k$ rejects the hypothesis of competitive conduct in 26 industries.

APPENDIX

Food and beverages are industries 11 to 22 in the National Account Systems of INEGI (Meat and Dairy, Fruit and Vegetables, Wheat Grinding, Corn Grinding, Coffee, Sugar, Oil and Fat, Animal food, Other Food Products, Alcoholic Beverages, Beer and Beverages).
Wood includes industries 29 and 30 (Wood and Wood Products).
Machinery and Equipment includes industries 51, 52 54 and 55 (Non-Electrical Machinery, Electrical Machinery, Electronic Instruments and Electric Instruments).
Basic Metals includes industries 46 and 47 (Primary Iron Metals and Primary Non-iron Metals).
Glass and Cement includes industries 43 and 44 (Glass and Glass Products and Cement).
Chemical includes industries 35, 37, 38, 39, 40, 41 and 42 (Basic Chemicals, Synthetic Resins, Pharmaceutical Products, Soaps and Detergents, Other Chemical Products, Rubber Products and Plastic Products).
Paper includes industries 31 and 32 (Paper Products and Printing/Publishing).
Textiles includes industries 24, 25, 26, 27 and 28 (Soft Fiber Textiles, Resilient Fiber Textiles, Other Textile Products and Apparel).
Metal products includes industries 48, 49 and 50 (Metal Furniture, Fabricated Metals and Other Metal Products).
Transport equipment includes industries 56, 57 and 58 (Automobiles, Autoparts and Transport Equipment).

Durable goods include industries 29, 30, 43, 44, 45, 46, 47, 48 49 50, 51, 52, 54, 55, 56, 57, 58 and 59.
Nondurable goods include industries 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 31, 32, 35, 37, 38, 39, 41, 42.
Manufacturing includes all two digit manufacturing industries except for 33, 34 and 36. For these industries we could not get accurate data.

## DATA

Output was obtained from the statistics for sectoral GDP published by INEGI in the National System Accounts. We used data at constant and nominal prices. These data were adjusted for indirect taxation and subsidies. The sectoral price deflator ( $p$ ) was obtained by combining the real and nominal data. The sources for labor data were the statistics on employment published by INEGI. From the sectoral employment data we inferred the yearly hours by assuming that each worker would work 40 hours per week with two weeks of holidays per year. This methodology appears arbitrary, however it appears to be the only available methodology. Labor income was obtained from the National Accounts System published by INEGI. The average wage ( $w$ ) is calculated from the ratio of labor income to yearly hours. The data on capital assets were taken from the publications by Banco de México. In its estimates, the Central Bank uses the methodology of perpetual inventories, which appears to be a reasonable way of estimating the capital assets. The relative price is calculated as the ratio of the industry deflator to the aggregate GDP deflator.

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