Explaining Reallocation's Apparent Negative Contribution to Growth in Deregulation-Era Developing Countries*

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Abstract

We investigate the findings in several recent studies using plant-level data that report negative growth in the reallocation component of aggregate labor productivity growth. This empirical finding is counter to almost all theoretical models of aggregate productivity growth, where inputs reallocate on average from lower-value to higher-value activities. We attempt to solve this puzzle for two countries in South America, Chile and Colombia. We cannot explain the puzzle away by conditioning productivity growth on two types of labor and capital instead of just one labor type. We do find that the puzzle disappears when we define aggregate productivity growth in terms of its impact on aggregate final demand. By this definition, labor reallocation contributes positively to economic growth in most years. We explore other possible reasons for the negative covariance between labor inputs and measured productivity growth.

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1 Introduction

Theory shows that aggregate productivity growth can increase even with no change in plant-level technical efficiencies if resources move from lower- to higher-valued activities. Policy reforms such as deregulation aim to stimulate growth by allowing resources such as capital or labor to move about more freely, presumably seeking out higher marginal product activities. The empirical puzzle in several recent studies - including a forthcoming World Bank report by Pages, Pierre, and Scarpetta (2009) - raise motivates this paper. Their findings indicate that despite deregulation, labor reallocation and productivity growth negatively co-vary in all 13 countries in Latin America and the Caribbean, including Chile and Colombia.

The World Bank report describes the finding as "worrisome" because even after years of liberalization in developing countries, inputs appear to be reallocating from higher-value-added-per-laborer activities to lower-value-added-per-laborer activities. This empirical finding is also counter to almost all theoretical models of aggregate productivity growth, such as vintage capital models and the trade and growth models, where inputs always reallocate from lower-value to higher-value activities as the economy evolves over time.[1]

We attempt to solve this puzzle for two countries in South America, Chile and Colombia. We focus principally on Chile in our empirical work, where the result is even more striking as the economy has experienced substantial growth since the reform-era of Pinochet, when many market-based policies were put into place. Indeed, Chile experienced the highest growth of any country in South America over the period. We use the plant-level data for manufacturing firms for the years 1979-1996 for Chile and 1977-1991 for Colombia, showing our data confirm the World Bank findings. For Chile, specifically, the reallocation component of aggregate labor productivity contributes negatively to growth in almost every year since 1985, when the economy began to recover from the international debt crisis. We also find, as others have elsewhere, that the covariance between value-added per laborer and labor share is negative. In the Chilean and Colombian data, this finding is true for every year of the 1980-1995 and 1978-1991 period, respectively.

[1] See, for example, Melitz (2003), Ericson and Pakes (1995), Caballero and Hammour (1994), Aghion and Howitt (1994), Aghion and Howitt (1992), or Lentz and Mortensen (2007).

We first check to see whether we can explain the puzzle by conditioning productivity growth on two types of labor and capital instead of just one labor type. We construct estimates of reallocation based on the productivity residual from a value-added production function that conditions these three different primary inputs. The puzzle remains just as stark, as inputs appear to continue to move in the direction of the lower productivity growth plants.

We then redefine aggregate productivity growth. We follow Petrin and Levinsohn (2008) so that the aggregation of plant-level changes of technical efficiency and input reallocations add up to changes in aggregate value added, holding primary input use constant. The definition aggregates plant-level observations to an aggregate(d) Solow residual that generalizes the Solow residual estimated using aggregate data. Aggregate reallocation is a weighted sum of movements of inputs across plants, with the change in the input multiplying the difference between the marginal product and marginal cost.

When one looks at the decomposition of this aggregate(d) Solow residual, no puzzle exists, as labor inputs appear to be reallocating in a systematic way from lower-valued to higher-valued activities. The contribution of reallocation to aggregate value added arising from either blue-collar or white-collar labor is positive in every year from 1985 to 1994 in Chile, with the exception of 1986 for blue-collar labor.

We suggest some alternative stories for why the aggregate labor productivity decomposition has negative reallocation in so many years. One possibility is that because estimated plant-level productivity growth includes a term related to plant-level price changes when only industry-level output deflators are available. If this price error negatively covaries with labor share then it explains at least part of the negative covariance between labor and measured productivity. The unmeasured plant-level price change may negatively covary with labor if plants face downward-sloping demand curves and an increase in labor signals an increase in output.

To investigate this possibility, we estimate markups in the plant-level setting using the suggestions by Hall (1990) and Basu and Fernald (2002). Consistent with our story, we find that annual markup levels and labor shares strongly negatively covary. Although final resolution of this question ultimately requires both price and quantities, we believe the evidence in this setting is at least consistent with the possibility that downward-sloping demand curves coupled with price measurement error explain this "negative reallocation puzzle."

The paper is organized as follows. Section 2 discusses aggregate labor productivity, its decomposition, and several empirical approximations with plant-level data. Section 3 fully characterizes the empirical puzzle. Section 4 shows the puzzle is robust to conditioning on capital when calculating plant-level productivity growth. Section 5 provides the Petrin-Levinsohn measurement and decomposition of aggregate productivity growth. Section 6 describes our alternative story and presents empirical evidence consistent with it. Section 7 concludes.

2 Decomposing Aggregate Labor Productivity

The growth rate of aggregate value added to aggregate labor is one of the statistics researchers often use to summarize the performance of an economy. The statistic is not a perfect indicator of changes in welfare except under special circumstances. However, aggregate labor productivity will typically be correlated with improvements in the standard of living because increases in it suggest the economy is generating more aggregate final demand, holding the number of laborers constant.

We denote the amount of labor input of plant i at time t by L_{it} and the value added at plant i at time t as VA_{it}. Then the ratio of aggregate value added to aggregate labor at time t - VL_t - is given as

$$VL_t = \frac{\sum_i VA_{it}}{\sum_i L_{it}}.$$

The source of the puzzle comes from the decomposition of this aggregate labor productivity into real productivity growth and reallocation components. In order to develop the decomposition, we rewrite VL_t as the sum of the product of plant-level labor shares and plant-level value-added per laborer. To do so, let $s_{it} = \frac{L_{it}}{L_t}$ be labor share of plant i at time t, with $L_t = \sum_i L_{it}$ the aggregate labor input in the economy. The ratio of aggregate value added to aggregate labor at time t, or VL_t, is then

$$VL_t = \sum_i \frac{L_{it}}{L_t} * \frac{VA_{it}}{L_{it}} = \sum_i s_{it} * VL_{it}$$

where VL_{it} is value-added per laborer, or

$$VL_{it} = \frac{VA_{it}}{L_{it}}.$$

In continuous time, we can write the change in VL_t as the sum of two components:

$$d(VL_t) = \sum_i s_{it}\, dVL_{it} + \sum_i ds_{it}\, VL_{it}. \tag{1}$$

The first term is the sum of plant-level changes in value added, where the plant-level weight is given by the labor share. This term is typically referred to as the real productivity growth term, with changes in plant-level value-added per laborer measuring plant-level productivity growth. The second term is the sum of changes in labor share times the plant-level value-added per laborer. This term is referred to as the reallocation term and it tracks labor share movements across different plant-level productivities.

Researchers often compare these two terms and their relative role in measured aggregate labor productivity. Indeed, the puzzle we investigate arises because the reallocation term is negative in many years in many developing countries, including strong performers like Chile. This finding is strange because theoretical models of reallocation almost universally have inputs moving in the direction of more valuable activities. It is also strange because the period has largely been one of deregulation of input and output markets, which generally would lead to a more fluid movement of inputs from lower-valued to higher-valued activities.

2.1 Approximations Using Discrete Time Data

There are several ways to approximate the continuous time growth using discrete data. We employ the four most popular approximations to see if the results are robust to approximation. All of these approximations satisfy the condition that the decompositions add up to the change in aggregate labor productivity growth calculated using

$$\frac{VL_t - VL_{t-1}}{VL_{t-1}}.$$

Although we do all calculations in growth rates with base terms VL_{t-1}, we restrict discussion to the change in levels in the numerator, $VL_t - VL_{t-1}$. The first approximation uses base-period shares to weight the changes in value added and end-period value-added per laborer to weight the change in labor share:

$$A_1 \equiv \sum_i s_{it-1} * \Delta VL_{it} + \sum_i VL_{it} * \Delta s_{it}, \tag{2}$$

where $\Delta VL_{it} = VL_{it} - VL_{it-1}$ and similarly for labor share. The second approximation is a Tornquist one, where we use averages of base-period and end-period for weights, and is given by

$$A_2 \equiv \sum_i \frac{s_{it} + s_{it-1}}{2} * \Delta VL_{it} + \sum_i \frac{VL_{it} + VL_{it-1}}{2} * \Delta s_{it}. \tag{3}$$

The third approximation uses the end-period labor share to weight the change in value added per laborer and the base-period value-added per laborer as the weight on the change in the labor share:

$$A_3 \equiv \sum_i s_{it} * \Delta VL_{it} + \sum_i VL_{it-1} * \Delta s_{it}. \tag{4}$$

A fourth way aggregate labor productivity is often decomposed is given as

$$A_4 \equiv \sum_i s_{it-1} * \Delta VL_{it} + \sum_i VL_{it-1} * \Delta s_{it} + \sum_i \Delta VL_{it} * \Delta s_{it}. \tag{5}$$

This last decomposition breaks out the "covariance" term, that is, the last term in A_4.

These four decompositions are related to one another. A_1 can be constructed by starting with A_4 and adding the covariance term entirely to the second term in A_4. A_2 can be constructed by dividing the covariance term equally between the first two terms in A_4. Finally, A_3 can be constructed by adding the covariance term entirely to the first component of A_4.

Pages, Pierre, and Scarpetta (2009) focus on the decomposition A_4. They report that the covariance term is negative in all 13 countries in Latin America and the Caribbean, including Chile and Colombia. They describe the finding as a "worrisome element" because the negative sign implies that plants with positive labor productivity growth appear to shed labor.

2.2 Chilean and Colombian Manufacturing Data

The Chilean and Colombian data span the periods of 1979-1995 and 1977-1991, respectively. Here, we provide a brief overview of these data. Numerous other productivity studies use them, and we refer the interested reader to those papers for a more detailed data description.[2]

The Chilean data, provided by Chile's Instituto Nacional de Estadistica (INE), are unbalanced panels and cover all manufacturing plants with at least 10 employees. The Colombian data from the Annual Manufacturing Survey, provided by Colombia's Departamento Administrativo Nacional de Estadistica (DANE), are also unbalanced panels and cover all plants for the years 1977-1982 and the plants with at least 10 employees for the years 1983-1991. In both data sets, plants are observed annually and they include a measure of nominal gross output, two types of labor, capital, and intermediate inputs, including fuels and electricity. Because of the way our plant-level data are reported, we treat plants as firms, although there are probably multi-plant firms. Labor is the number of man-years hired for production, and plants distinguish between their blue- and white- collar workers. Liu (1991) documents the method for constructing the real value of capital for the Chilean data, and we use the same method for the Colombian data.[3]

Plant i's price and quantity at time t are given by P_{it} and Q_{it}. As with most plant-level data, we also do not observe plant-level prices, so we deflate plant-level revenues $P_{it}Q_{it}$ with 3-digit industry gross output deflators, with P_{st} denoting the price index for industry s at time t. We define double-deflated value added as

$$VA_{it} = \frac{P_{it}Q_{it}}{P_t} - \frac{\sum_j P_{jt}M_{ijt}}{P_t^M},$$

where P_{jt} is the price of input j at time t and M_{ijt} is the amount of j used as an intermediate

[2] See Liu (1991), Liu (1993), Liu and Tybout (1996), and Levinsohn and Petrin (2003) for the Chilean data and Roberts (1996) for the Colombian data.

[3] For the Chilean data, the real value of capital is a weighted average of the peso value of depreciated buildings, machinery, and vehicles. We assume each of which has a depreciation rate of 5%, 10%, and 20%, respectively. They don't report initial capital stock for some plants, although they record investment. When possible, we used a capital series that they report for a subsequent base year. For a small number of plants, they don't report capital stock in any year. We estimated a projected initial capital stock based on other reported plant observables for these plants. We then used the investment data to fill out the capital stock data.

input in i's production, and we deflate expenditures on intermediate inputs using a 3-digit industry price index for materials, which we denote P_t^M. We define single-deflated value added using only the industry gross output price deflators:

$$VA_{it} = \frac{P_{it}Q_{it} - \sum_j P_{jt}M_{ijt}}{P_{st}}.$$

Finally, we use the consumer price index as a common deflator across all plants in any year to calculate an alternative measure of single-deflated value added. Qualitatively, the results across these different value-added specifications are similar, so we primarily discuss the double-deflated value-added results.

3 Negative Reallocation Growth

Tables 1 through 3 present the negative reallocation growth puzzle for Chile that researchers have also confronted in other countries.[4] The first column in Table 1 is the growth rate of aggregate value added and the second column is the growth rate of aggregate labor productivity (ALP). Aggregate value added grew an average of 3.17 % relative to 1.92 % for ALP, and their standard deviations were also not so different at 8.59 versus 7.13, respectively. They covary over time but are by no means one-to-one.

The Pinochet market-based reforms were put into place for the most part by 1980 and were followed by an overall period of strong economic growth. The main exception is the severe economic downturn in the early 1980s, brought about by the Debt Crisis and the fall in the price of copper, a major Chilean export.

In columns 3 and 4 in Table 1, we report the decomposition of APL into its real productivity growth and reallocation components. We use the Tornquist-Divisia approximation here, and in Tables 2 and 3 report the full set of approximations. Column 3 shows that real productivity growth is also increasing over almost this entire period, at least at the plants

[4] The results in this table are exclusively based on continuing plants as they are the only plants that contribute to the reallocation component of labor productivity growth. Adding back entry and exit does not at all affect our qualitative results, as these plants typically contribute only a small share of aggregate value added in their first/last year of existence.

that most heavily use labor.

The final column in Table 1 shows the reallocation anomaly. Except for 1994, after 1982 reallocation contributes negatively to aggregate labor productivity. Put another way, labor shares appear to move in the direction of lower value-added per laborer in Chile in the midst of remarkably strong economic growth.

This finding contrasts with our beliefs regarding growth in market-oriented settings with deregulated input and output prices. Almost all theoretical models based on growth via reallocation of inputs have inputs moving systematically from lower-valued activities to higher-valued activities. The prices act as signals of where inputs should move, and profit-maximizing entrepreneurs then respond by moving inputs in the directions of their most-valued activities. Indeed, this allocative efficiency story is a principle motivation policy makers give for deregulation.

Table 2 reports measured technical efficiency across different approximations and Table 3 does the same for reallocation. Table 2 shows that technical efficiency growth remains positive in almost all years regardless of how it is weighted in the aggregation. One additional observation is that the estimated aggregate growth rate does fall as the weights move from the prior to the current period.

Table 3 shows that systematic negative growth from reallocation remains robust to the approximation used. For the first two approximations, every year after 1982 has negative aggregate reallocation growth. For the current-period weight, six of the fifteen years are negative. We see a move in the positive direction across approximations as we move from the prior-period to the current-period weights. The final column shows that the covariance between labor share and labor productivity is negative in every year of the data.

Turning to the findings from the Colombian data, Tables 7, 8, and 9 correspond to the Chilean results of Tables 1, 2, and 3, respectively. All tables confirm that the findings from Table 1 through Table 3 are still valid for Colombia. The negative reallocation growth in the final column of Table 7 provides the reallocation anomaly for Colombia. Table 8 shows that technical efficiency growth remains positive in almost all years, regardless of how it is weighted in the aggregation. Although less striking than the results from the Chilean data,

Table 9 shows the presence of systematic negative growth from reallocation. As in Chile, a move in the positive direction across approximations exists as we move from the prior-period to the current-period weights.

Overall, for a country that is experiencing remarkable growth, to have market forces working systematically to allocate inputs to the lower-value activities does seem puzzling.

4 Controlling for Capital and Labor Heterogeneity

As Pages, Pierre, and Scarpetta (2009) point out, the possibility exists that our use of labor productivity as a measure of plant-level productivity may drive the above results. If what we are observing is labor moving away from plants that have more capital, substitution away from labor may explain the puzzle. Although policy makers might not view this explanation as innocuous, it seems less troubling than an economy that systematically moves inputs in the direction of lower-value activities.

In order to see whether we can explain away this result by conditioning on other primary inputs, we posit a value-added production function and estimate its parameters to recover a productivity residual. The value-added technical efficiency shock $ln\omega_i^v$ is derived from the value-added production function and can be expressed as

$$ln\omega_i^v = ln(VA_i) - \sum_k \varepsilon_{ik}^v lnX_{ik}, \tag{6}$$

with X_k denoting the vector of primary inputs and ε_{ik}^v denoting the elasticity of (value-added) output with respect to the primary inputs.

Our estimation approach follows Petrin and Levinsohn (2008) closely, and we posit three primary inputs as regressors: production (blue-collar) workers L_{it}^P, non-production (white-collar) workers L_{it}^{NP}, and capital K_{it}. We estimate production functions separately for each 3-digit industry code using OLS and the proxy method from Wooldridge (2005) that modifies Levinsohn and Petrin (2003), which we call Wooldridge-LP.[5] Given any estimator of

[5] The approach is robust to the comment by Ackerberg, Caves, and Frazer (2008) and is one line of code in Stata.

production function coefficients, our estimate of plant-level technical efficiency is

$$\widehat{ln\omega^v}_{it} = ln(VA_{it}) - \left(\widehat{\epsilon^v}_{jP}\, lnL_{it}^P + \widehat{\epsilon^v}_{jNP}\, lnL_{it}^{NP} + \widehat{\epsilon^v}_{jK}\, lnK_{it}\right),$$

where $\widehat{\epsilon^v}_{j\cdot}$ denote the estimated elasticities of value added with respect to the inputs in industry j.

The decomposition terms for reallocation and real productivity growth are identical to the previous aggregate productivity decompositions for labor productivity. The only difference is that the estimated residual $\widehat{\ln\omega}_{it}^{v}$ from the value-added production function approach replaces plant-level labor productivity VL_{it}.

Table 4 confirms the negative reallocation growth patterns for labor productivity in Chile are robust to conditioning on capital. Column 2 reports technical efficiency growth, and in most years technical efficiency is positive. Columns 3-5 show the reallocation term is negative in every year after 1984 except for 1986 and 1994, regardless of the weights used.[6] Similar results are reported in Table 10, where we use the Colombian data. Although less apparent than the findings in Table 4, columns 3-5 in Table 10 show the negative productivity reallocation persists for half of the 14 years in the Colombian data even when conditioning on capital.

We note that neither our measure for capital nor our measure for labor account for unobserved variation in utilization. Unobserved utilization would appear in the production function as an increase in technical efficiency. The puzzle could also be explained by unobserved labor or capital utilization if it were negatively correlated with labor. For example, within-plant substitution between hiring new bodies and increasing utilization rates might play a role in the negative covariance.

[6] These results are robust to the different production function estimators and to the three definitions of value added. Stata programs are available from the authors.

5 Growth in Final Demand from Input Reallocation

We change the definition of productivity growth. We follow Petrin and Levinsohn (2008) that the aggregation of plant-level changes of technical efficiency and input reallocations add up to changes in aggregate final demand, holding primary input use constant. This definition aggregates plant-level observations to an aggregate(d) Solow residual that generalizes the Solow residual estimated using aggregate data. Then aggregate reallocation is a weighted sum of movements of inputs across plants, with the change in the input multiplying the difference between marginal product and marginal cost.

We describe our findings briefly now and urge interested readers to pursue the details of this aggregate(d) Solow residual and its decomposition in the next section. Using this definition of reallocation, we find the opposite of what is found for the reallocation term from aggregate labor productivity. Looking at Table 5, one can see that in Chile the contribution of reallocation arising from either white-collar or blue-collar labor is positive in every year from 1985 to 1994, with the exception of 1986 for blue-collar labor. Thus, for this index, no "reallocation puzzle" exists, as labor inputs appear to be reallocating in a systematic way from lower-valued to higher-valued activities.

5.1 Petrin and Levinsohn (2008) Growth

Although plant-level data do not generally record the amount of a plant's output that ultimately goes to final demand, we are able to use the Growth Accounting Identity, which shows aggregate final demand is equal to aggregate value added. We can measure aggregate value added from plant-level measures of value-added aggregated.

For any definition of plant-level value added, we define the Domar weight as the plant's share of value added $D_i^v = \frac{VA_i}{\sum_i VA_i}$. We calculate aggregate productivity growth as

$$PL = \sum_i D_i^v dlnVA_i - \sum_i \sum_k s_{ik} dlnX_{ik}, \tag{7}$$

with the cost share for the kth primary input given as $s_{ik} = \frac{W_{ik}X_{ik}}{\sum_i VA_i}$. The final term deducts changes in the cost of primary inputs from the change in aggregate final demand to account for the use of more or fewer inputs in production.[7]

In levels, we can decompose this definition of aggregate productivity growth as follows:

$$\sum_i \sum_k (P_i \frac{\partial Q_i}{\partial X_{ik}} - W_{ik}) dX_{ik} + \sum_i \sum_j (P_i \frac{\partial Q_i}{\partial M_{ij}} - P_j) dM_{ij} - \sum_i P_i dF_i + \sum_i P_i d\omega_i, \quad (8)$$

where $\frac{\partial Q}{\partial X_{ik}}$ and $\frac{\partial Q}{\partial M_{ij}}$ are the partial derivatives of the output production function with respect to the kth primary input and the jth intermediate input, respectively, dM_{ij} is the change in intermediate input j at plant i, dF_i is the change in fixed and sunk costs, and $d\omega_i$ is defined as the remaining output. The aggregate reallocation effect is the sum of the first two terms in (8), and the final term is the aggregate real productivity growth term.

Equation (8) shows that under this definition of aggregate productivity growth, if at every firm every marginal product is equated with every marginal cost, further reallocation cannot increase growth, as all allocative efficiency gains have been achieved. However, if we see market power (i.e., markups) or frictions, such as adjustment costs or taxes, or other characteristics of the economy that lead to a divergence between the marginal product and the marginal cost, the reallocation of inputs can increase aggregate productivity growth.

We estimate the decomposition of Petrin-Levinsohn aggregate productivity growth in growth rates using the value-added production function formulation, which is given by

$$\sum_i \sum_k (D_i^v \varepsilon_{ik}^v - s_{ik}) dlnX_{ik} + \sum_i \sum_j (D_i^v \varepsilon_{ij}^v - s_{ij}) dlnM_{ij} - \sum_i D_i^v dlnF_i^v + \sum_i D_i^v dln\omega_i^v, \quad (9)$$

where the elasticities are those for the value-added production function, and lnF^v denotes the growth rate in fixed costs divided by one minus the ratio of intermediate inputs expenditures to revenues.[8] Our estimate of aggregate technical efficiency is given by our approximation

[7] Petrin and Levinsohn (2008) extend Basu and Fernald (2002) and show the assumptions under which this measure tracks changes in welfare to first-order.

[8] Equation (8) can be rewritten in growth rates as

$$\sum_i D_i \sum_k (\varepsilon_{ik} - c_{ik}) dlnX_{ik} + \sum_i D_i \sum_j (\varepsilon_{ij} - c_{ij}) dlnM_{ij} - \sum_i D_i dlnF_i + \sum_i D_i dln\omega_i, \quad (10)$$

where D_i is the Domar weight, ε_{ik} and ε_{ij} are the elasticities of output with respect to primary and intermediate inputs, $c_{ik} = \frac{W_{ik} X_{ik}}{P_i Q_i}$ and $c_{ij} = \frac{P_j M_{ij}}{P_i Q_i}$ are the respective plant-specific revenue shares for both primary and to $\sum_i D_i^v dln\omega_i^v$. Our estimate of aggregate growth arising from blue-collar and white-collar worker reallocation is given by our approximation to $\sum_i (D_i^v \varepsilon_{ik}^v - s_{ik}) dlnX_{ik}$ for k equal to both types.

Table 5 shows that aggregate productivity growth in Chile under this definition tracks value-added growth rather closely, as the primary input terms for labor are small. The final two columns show that reallocation growth for blue- and white-collar labor are positive for most years in the sample. Table 11 confirms these findings are robust to the data from Colombia, except for the white-collar worker reallocation shown in the last column.

6 Unobserved Prices and Input Utilization

The estimated productivity residual is affected by the fact that the typical measure of gross output used in plant-level data is not Q_{it} but instead is the nominal value of total shipments $P_{it}Q_{it}$ deflated by an industry price deflator P_t:

$$ln\frac{P_{it}Q_{it}}{P_t} = lnQ_{it} + ln(P_{it} - P_t).$$

In terms of estimated growth rates, the size of the price measurement error added to the growth in technical efficiency is $ln(P_{it} - P_t) - ln(P_{it-1} - P_{t-1})$, so for the estimated technical efficiency residual, we have

$$\Delta\widehat{\ln\omega}_i^V = \Delta\ln\omega_i^V + \ln(\frac{P_{it}}{P_{it-1}}) - \ln(\frac{P_T}{P_{T-1}}).$$

The puzzle is the negative covariance in the estimated residuals and labor share.

Given the existence of this price measurement error in estimated productivity, one possibility is that the negative covariance between labor inputs and measured productivity may just reflect that estimated productivity falls because the price falls when output (and inputs) increases. This possibility requires plants to face downward-sloping demand curves, that is,

intermediate inputs, and $dlnF_i$ and $dln\omega_i$ denoting the growth rates in fixed costs and technical efficiency, with the base given by Q_i.

some kind of market power. A second possibility is that unobserved utilization of labor or capital is negatively correlated with measured labor inputs.

To investigate the possibility that unobserved price variation plays a role in the estimated productivity residual, we estimate markups in the plant-level setting using the suggestions by Hall (1990) and Basu and Fernald (2002). The markup of firm i is $\mu_{it} = \frac{P_{it}}{MC_{it}}$, where MC_{it} is firm i's marginal cost at time t, so

$$\Delta \ln \mu_{it} = \Delta \ln (\frac{P_{it}}{MC_{it}}) = \ln P_{it} - \ln P_{it-1} - (\ln MC_{it} - \ln MC_{it-1}).$$

Thus the change in markups contains the change in price plus the change in marginal cost. If the technology has constant returns so marginal costs are constant across the relevant range of output then the change in the markup is equal to the change in the product price. We look to see whether markups strongly negatively covary with labor.

We estimate

$$\hat{\mu}_{ikt} = \frac{\hat{\varepsilon}_{ik}}{s_{ikt}} \tag{11}$$

for both white-collar and blue-collar labor for each plant-year labor observation. We average the two estimates to obtain an estimate for each plant-year markup.

Table 6 reports results of three different covariance terms for Chile, using Wooldridge-LP estimates of production function coefficients. Column 2 is the covariance between change in markups and change in labor share. It is negative in every year, suggesting plant-level markups strongly negatively covary with plant-level labor inputs. Column 3 shows that plants with current high markups have reduced labor shares over the previous period and those with low current markups have increased labor shares over the previous period. Table 12 reports the results of three different covariance terms for Colombia. Columns 2-4 confirm findings similar to the ones from the Chilean data. These results are consistent with a story of plant-level price changes playing a role the plant-level estimated productivity residual.

7 Conclusions

The empirical puzzle several empirical recent studies - including a forthcoming World Bank report by Pages, Pierre, and Scarpetta (2009) - raise motivates the paper. Their findings indicate that despite deregulation, the reallocation component of aggregate labor productivity growth is negative in many years. In Chile, the result is especially striking, as the economy has experienced substantial growth since the reform-era of Pinochet, when many market-based policies were put into place. This empirical finding is also counter to almost all theoretical models of aggregate productivity growth, where inputs always reallocate from lower-value to higher-value activities as the economy evolves over time.

We attempt to solve this puzzle for two countries in South America, Chile and Colombia, using the plant-level data for the manufacturing industries. We first check to see whether we can explain the puzzle by conditioning productivity growth on two types of labor and capital instead of just one labor type. The puzzle remains just as stark.

We then redefine aggregate productivity growth. We insist that the aggregation of plant-level changes of technical efficiency and input reallocations add up to changes in aggregate final demand, holding primary input use constant. We find the opposite of what is found with the reallocation term from aggregate labor productivity. The contribution of reallocation to aggregate value added arising from either blue-collar or white-collar labor in Chile is positive in every year from 1985-1994.

We suggest an alternative explanation for why the aggregate labor productivity decomposition has negative reallocation in so many years. We hypothesize that the negative covariance between labor inputs and measured productivity may arise from the reduction in price that occurs when plants increase output, which the increased input use reflects. To investigate this possibility, we estimate markups, and, consistent with our story we find that annual markup levels and labor shares strongly negatively covary. Final resolution of this question ultimately requires both price and quantities to be observed.

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Table 1
Growth Rate of Aggregate Value Added and Aggregate Labor Productivity
Chilean Manufacturing, 1980 - 1995

	Value Added $\frac{\sum_i (VA_{it} - VA_{it-1})}{\sum_i VA_{it-1}}$	Labor Productivity $\frac{VL_t - VL_{t-1}}{VL_{t-1}}$	Technical Efficiency $(\sum_i \bar{s}_{it} \Delta VL_{it})/VL_{t-1}$	Reallocation $(\sum_i \overline{VL}_{it} \Delta s_{it})/VL_{t-1}$
1980	3.20	9.83	2.54	7.29
1981	5.90	13.41	10.20	3.21
1982	-24.38	-7.53	-13.51	5.98
1983	-0.34	7.03	7.85	-0.82
1984	-3.51	-9.96	-2.84	-7.12
1985	13.54	3.55	6.94	-3.39
1986	9.78	5.02	8.89	-3.87
1987	-2.89	-14.38	-7.54	-6.84
1988	7.71	1.33	4.97	-3.64
1989	6.87	0.01	2.54	-2.54
1990	4.90	2.43	4.03	-1.60
1991	6.13	3.39	4.25	-0.86
1992	8.96	3.92	8.46	-4.54
1993	6.91	4.75	6.00	-1.25
1994	3.51	2.19	1.19	1.00
1995	4.40	5.65	7.22	-1.57
Average	3.17	1.92	3.20	-1.29
St. Dev.	8.59	7.13	6.37	4.05

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it} / \sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$, $\overline{VL}_{it} := (VL_{it} + VL_{it-1})/2$, $s_{it} := L_{it}/\sum_i L_{it}$,, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 2
Growth Rate of Labor Productivity and
Its Technical Efficiency Component, Chile

	Labor Productivity	Technical Efficiency		
	$\frac{VL_t - VL_{t-1}}{VL_{t-1}}$	$\sum_i s_{it-1} \Delta VL_{it}$	$\sum_i \bar{s}_{it} \Delta VL_{it}$	$\sum_i s_{it} \Delta VL_{it}$
1980	9.83	5.18	2.54	-0.10
1981	13.41	11.09	10.20	9.30
1982	-7.53	-11.77	-13.51	-15.25
1983	7.03	9.03	7.85	6.67
1984	-9.96	-1.89	-2.84	-3.80
1985	3.55	8.16	6.94	5.71
1986	5.02	11.17	8.89	6.61
1987	-14.38	-6.25	-7.54	-8.82
1988	1.33	6.37	4.97	3.57
1989	0.01	5.34	2.54	-0.25
1990	2.43	7.90	4.03	0.15
1991	3.39	6.93	4.25	1.57
1992	3.92	10.39	8.46	6.53
1993	4.75	8.14	6.00	3.86
1994	2.19	3.06	1.19	-0.68
1995	5.65	9.17	7.22	5.28
Average	1.92	5.13	3.20	1.27
St. Dev.	7.13	6.48	6.37	6.36

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it} / \sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$,, $s_{it} := L_{it}/\sum_i L_{it}$, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 3
Labor Productivity Growth from
Reallocation across Plants, Chile

	Labor Prod.	Reallocation			Covariance
	$\frac{VL_t - VL_{t-1}}{VL_{t-1}}$	$\sum_i VL_{it-1}\Delta s_{it}$	$\sum_i \overline{VL}_{it}\Delta s_{it}$	$\sum_i VL_{it}\Delta s_{it}$	$\sum_i \Delta s_{it}\Delta VL_{it}$
1980	9.83	4.65	7.29	9.93	-5.28
1981	13.41	2.32	3.21	4.11	-1.79
1982	-7.53	4.24	5.98	7.72	-3.48
1983	7.03	-2.00	-0.82	0.36	-2.36
1984	-9.96	-8.08	-7.12	-6.17	-1.91
1985	3.55	-4.61	-3.39	-2.16	-2.45
1986	5.02	-6.15	-3.87	-1.59	-4.56
1987	-14.38	-8.12	-6.84	-5.55	-2.57
1988	1.33	-5.04	-3.64	-2.24	-2.80
1989	0.01	-5.33	-2.54	0.26	-5.59
1990	2.43	-5.47	-1.60	2.27	-7.75
1991	3.39	-3.55	-0.86	1.82	-5.36
1992	3.92	-6.47	-4.54	-2.62	-3.85
1993	4.75	-3.39	-1.25	0.89	-4.28
1994	2.19	-0.87	1.00	2.87	-3.74
1995	5.65	-3.52	-1.57	0.37	-3.88
Average	1.92	-3.21	-1.29	0.64	-3.85
St. Dev.	7.13	3.98	4.05	4.28	1.60

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it}/\sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$, $\overline{VL}_{it} := (VL_{it} + VL_{it-1})/2$, $s_{it} := L_{it}/\sum_i L_{it}$, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 4
Productivity Growth Conditional on
Blue- and White-Collar Labor and Capital, Chile

	Value Added	Technical Efficiency	Reallocation		
	$\frac{\sum_i (VA_{it}-VA_{it-1})}{\sum_i VA_{it}}$	$\sum_i \bar{s}_{it}\Delta \ln \widehat{w}^v_{it}$	$\sum_i \ln \widehat{w}^v_{it}\Delta s_{it}$	$\sum_i \overline{\ln \widehat{w}^v}_{it}\Delta s_{it}$	$\sum_i \ln \widehat{w}^v_{it-1}\Delta s_{it}$
1980	3.20	-0.68	7.00	7.08	7.16
1981	5.90	1.20	4.05	3.98	3.90
1982	-24.38	-2.72	4.87	4.96	5.05
1983	-0.34	-0.99	1.53	1.59	1.66
1984	-3.51	0.38	-3.60	-3.57	-3.55
1985	13.54	0.35	-0.89	-0.78	-0.68
1986	9.78	1.46	1.25	1.50	1.76
1987	-2.89	-0.67	-3.98	-3.88	-3.79
1988	7.71	1.07	-0.36	-0.30	-0.23
1989	6.87	-0.52	-1.32	-1.16	-1.01
1990	4.90	1.41	-0.45	-0.31	-0.17
1991	6.13	0.71	-1.56	-1.39	-1.22
1992	8.96	1.26	-2.51	-2.43	-2.34
1993	6.91	0.69	-1.17	-0.97	-0.76
1994	3.51	0.03	0.00	0.08	0.15
1995	4.40	0.22	-1.44	-1.29	-1.14
Average	3.17	0.20	0.09	0.19	0.30
St. Dev.	8.59	1.11	3.02	3.00	2.99

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $\ln\hat{w}^v_{it}$ is the plant-level technical efficiency computed by using value-added production function coefficients that are estimated by Wooldridge (2005), $\overline{\ln \hat{w}^v_{it}} := (\ln \hat{w}^v_{it} + \ln \hat{w}^v_{it-1})/2$, $s_{it} := L_{it}/\sum_i L_{it}, \bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 5
The Change in Final Demand's Reallocation Component, Chile

	Value Added	Aggregate Prod. Growth	Reallocation White Collar	Reallocation Blue Collar
1980	3.20	2.40	-0.36	-0.23
1981	5.90	6.56	-0.07	-0.71
1982	-24.38	-20.97	-0.21	-2.03
1983	-0.34	0.08	-0.47	0.03
1984	-3.51	-4.00	-0.15	1.14
1985	13.54	12.87	0.79	1.10
1986	9.78	8.58	1.28	-0.46
1987	-2.89	-3.96	1.42	0.86
1988	7.71	6.92	1.42	0.00
1989	6.87	5.83	0.67	1.36
1990	4.90	4.60	0.02	0.91
1991	6.13	5.68	0.52	0.85
1992	8.96	8.51	0.21	1.22
1993	6.91	6.63	0.82	0.50
1994	3.51	3.19	0.34	0.35
1995	4.40	4.59	-0.22	-0.25
Average	3.17	2.97	0.38	0.29
St. Dev.	8.59	7.75	0.64	0.90

Note: Our definition of aggregate productivity growth (APG) is the one Petrin and Levinsohn (2008) propose. It is defined as aggregate change in final demand, holding input constant. The last two columns show the input specific reallocation components of APG: non-production (White) and production (Blue) labors. The results are for continuing firms only.

Table 6

Plant-Level Comovements between Labor Inputs and Markups, Chile

	Value Added	$\sum_i \Delta s_{it}\Delta\mu_{it}$	$\sum_i \Delta s_{it}\mu_{it}$	$\sum_i \Delta s_{it}\mu_{it-1}$
1980	3.20	-4.04	17.16	20.57
1981	5.90	-5.27	8.66	13.41
1982	-24.38	-3.94	12.24	15.82
1983	-0.34	-4.01	5.10	8.74
1984	-3.51	-8.20	-14.46	-6.48
1985	13.54	-3.65	-0.25	3.06
1986	9.78	-9.61	-1.30	8.10
1987	-2.89	-11.21	-16.90	-5.99
1988	7.71	-0.65	3.39	3.87
1989	6.87	-5.43	-5.31	0.18
1990	4.90	-9.79	-5.87	3.87
1991	6.13	-14.54	-3.55	10.92
1992	8.96	-6.62	-9.05	-2.54
1993	6.91	-9.07	-5.57	3.30
1994	3.51	-7.14	-0.05	6.93
1995	4.40	-8.52	-6.78	1.51
Average	3.17	-6.98	-1.41	5.33
St. Dev.	8.59	3.48	9.15	7.51

Note: $\mu_{it} := (\mu_{it}^{blue} + \mu_{it}^{white})/2$, where $\mu_{it}^{k} := \hat{\epsilon}^{k}/\hat{s}_{it}^{k}$, $\hat{\epsilon}^{k}$ is the estimate of the type-k labor elasticity ($k \in \{white, blue\}$), $\hat{s}_{it}^{k} := w_{it}^{k}L_{it}^{k}/VA_{it}$, w^{k} is the wage rate for the type-k worker, L_{it}^{k} is the number of the type-k labor at plant i, and VA_{it} is the double-deflated value added at plant i. $s_{it} := L_{it}/\sum_i L_{it}$, and $L_{it} := L_{it}^{bule} + L_{it}^{white}$. Markups are winsored at 1%. The results are for continuing firms only.

Table 7
Growth Rate of Aggregate Value Added and Aggregate Labor Productivity
Colombian Manufacturing, 1978 - 1991

	Value Added $\frac{\sum_i (VA_{it}-VA_{it-1})}{\sum_i VA_{it-1}}$	Labor Productivity $\frac{VL_t-VL_{t-1}}{VL_{t-1}}$	Technical Efficiency $(\sum_i \bar{s}_{it}\Delta VL_{it})/VL_{t-1}$	Reallocation $(\sum_i \overline{VL}_{it}\Delta s_{it})/VL_{t-1}$
1978	9.22	7.71	7.99	-0.30
1979	7.24	1.14	-0.64	1.79
1980	5.59	10.29	9.48	0.80
1981	-8.70	-6.06	-7.70	1.54
1982	-4.24	0.77	0.91	-0.14
1983	1.96	5.00	3.58	1.41
1984	6.15	8.22	7.63	0.57
1985	5.77	12.71	21.07	-8.37
1986	13.29	5.91	14.35	-8.44
1987	-10.49	-10.65	-6.37	-4.28
1988	10.90	11.99	15.39	-3.42
1989	1.63	1.21	3.53	-2.33
1990	3.43	3.70	3.16	0.48
1991	0.20	1.00	0.77	0.22
Average	3.00	3.78	5.23	-1.46
St. Dev.	6.97	6.60	8.10	3.46

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it}/\sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$, $\overline{VL}_{it} := (VL_{it} + VL_{it-1})/2$, $s_{it} := L_{it}/\sum_i L_{it}$, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 8
Growth Rate of Labor Productivity and
Its Technical Efficiency Component, Colombia

	Labor Productivity	Technical Efficiency		
	$\frac{VL_t - VL_{t-1}}{VL_{t-1}}$	$\sum_i s_{it-1}\Delta VL_{it}$	$\sum_i \bar{s}_{it}\Delta VL_{it}$	$\sum_i s_{it}\Delta VL_{it}$
1978	7.71	10.44	7.99	5.54
1979	1.14	1.80	-0.64	-3.09
1980	10.29	11.06	9.48	7.89
1981	-6.06	-6.35	-7.70	-9.05
1982	0.77	2.69	0.91	-0.87
1983	5.00	4.88	3.58	2.28
1984	8.22	8.74	7.63	6.51
1985	12.71	30.27	21.07	11.88
1986	5.91	20.12	14.35	8.57
1987	-10.65	-4.16	-6.37	-8.58
1988	11.99	21.87	15.39	8.91
1989	1.21	6.17	3.53	0.90
1990	3.70	6.93	3.16	-0.62
1991	1.00	4.81	0.77	-3.26
Average	3.78	8.52	5.23	1.93
St. Dev.	6.60	9.97	8.10	6.56

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it}/\sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$, $s_{it} := L_{it}/\sum_i L_{it}$, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 9
Labor Productivity Growth from
Reallocation across Plants, Colombia

	Labor Prod.	Reallocation			Covariance
	$\frac{VL_t - VL_{t-1}}{VL_{t-1}}$	$\sum_i VL_{it-1}\Delta s_{it}$	$\sum_i \overline{VL}_{it}\Delta s_{it}$	$\sum_i VL_{it}\Delta s_{it}$	$\sum_i \Delta s_{it}\Delta VL_{it}$
1978	7.71	-2.74	-0.30	2.15	-4.91
1979	1.14	-0.66	1.79	4.22	-4.89
1980	10.29	-0.78	0.80	2.38	-3.17
1981	-6.06	0.28	1.54	2.89	-2.70
1982	0.77	-1.92	-0.14	1.60	-3.55
1983	5.00	0.11	1.41	2.71	-2.60
1984	8.22	-0.52	0.57	1.68	-2.23
1985	12.71	-17.56	-8.37	0.83	-18.39
1986	5.91	-14.21	-8.44	-2.67	-11.55
1987	-10.65	-6.49	-4.28	-2.08	-4.42
1988	11.99	-9.88	-3.42	2.87	-12.95
1989	1.21	-4.96	-2.33	0.26	-5.28
1990	3.70	-3.23	0.48	4.25	-7.55
1991	1.00	-3.81	0.22	4.25	-8.08
Average	3.78	-4.74	-1.46	1.81	-6.59
St. Dev.	6.60	5.53	3.46	2.15	4.73

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it}/\sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$, $\overline{VL}_{it} := (VL_{it} + VL_{it-1})/2$, $s_{it} := L_{it}/\sum_i L_{it}$, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 10
Productivity Growth Conditional on
Blue- and White-Collar Labor and Capital, Colombia

	Value Added	Technical Efficiency	Reallocation		
	$\frac{\sum_i (VA_{it} - VA_{it-1})}{\sum_i VA_{it}}$	$\sum_i \bar{s}_{it} \Delta \ln \hat{w}^v_{it}$	$\sum_i \Delta s_{it} \ln \hat{w}^v_{it}$	$\sum_i \Delta s_{it} \overline{\ln \hat{w}^v}_{it}$	$\sum_i \Delta s_{it} \ln \hat{w}^v_{it-1}$
1978	9.22	0.16	-0.49	-0.29	-0.09
1979	7.24	-0.01	-0.83	-0.70	-0.57
1980	5.59	0.46	-0.43	-0.31	-0.19
1981	-8.70	-1.75	0.55	0.66	0.77
1982	-4.24	-0.34	-1.10	-1.02	-0.93
1983	1.96	-0.19	0.63	0.72	0.80
1984	6.15	0.51	0.76	0.85	0.95
1985	5.77	0.28	0.77	0.95	1.13
1986	13.29	0.15	-2.44	-2.30	-2.17
1987	-10.49	-0.32	-3.21	-2.76	-2.31
1988	10.90	0.28	0.71	1.27	1.82
1989	1.63	0.12	-0.91	-0.78	-0.66
1990	3.43	0.35	0.25	0.35	0.46
1991	0.20	-0.08	1.53	1.65	1.76
Average	3.00	-0.03	-0.30	-0.12	0.06
St. Dev.	6.97	0.56	1.33	1.30	1.29

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $\ln\hat{w}^v_{it}$ is the plant-level technical efficiency computed by using value-added production function coefficients that are estimated by Wooldridge (2005), $\overline{\ln \hat{w}^v_{it}} := (\ln \hat{w}^v_{it} + \ln \hat{w}^v_{it-1})/2$, $s_{it} := L_{it} / \sum_i L_{it}, \bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.

Table 11
The Change in Final Demand's Reallocation Component, Colombia

	Value Added	Aggregate Prod. Growth	Reallocation White Collar	Reallocation Blue Collar
1978	9.22	8.33	1.53	1.04
1979	7.24	6.38	0.48	1.40
1980	5.59	5.57	1.31	0.69
1981	-8.70	-8.1	0.33	-0.05
1982	-4.24	-2.94	0.13	-0.01
1983	1.96	2.87	-0.16	-0.34
1984	6.15	6.79	-0.30	-0.36
1985	5.77	7.35	-0.08	-2.62
1986	13.29	13.42	1.16	-1.77
1987	-10.49	-11.09	0.55	0.81
1988	10.90	11.08	1.02	0.40
1989	1.63	1.34	0.56	-0.58
1990	3.43	3.29	1.65	-0.47
1991	0.20	-13.2	-11.76	0.13
Average	3.00	2.22	-0.26	-0.12
St. Dev.	6.97	8.17	3.37	1.07

Note: Our definition of aggregate productivity growth (APG) is the one Petrin and Levinsohn (2008) propose. It is defined as aggregate change in final demand, holding input constant. The last two columns show the input specific reallocation components of APG: non-production (White) and production (Blue) labors. The results are for continuing firms only.

Table 12
Plant-Level Comovements between Labor Inputs and Markups, Colombia

	Value Added	$\sum_i \Delta s_{it} \Delta \mu_{it}$	$\sum_i \Delta s_{it} \mu_{it}$	$\sum_i \Delta s_{it} \mu_{it-1}$
1978	9.22	-2.01	0.13	1.55
1979	7.24	-2.27	-0.89	1.10
1980	5.59	-2.37	0.48	2.31
1981	-8.70	-3.50	2.06	5.08
1982	-4.24	-5.60	-0.34	4.88
1983	1.96	0.48	1.92	1.20
1984	6.15	-1.57	1.41	2.73
1985	5.77	-5.85	-2.94	2.65
1986	13.29	-3.74	-9.36	-6.01
1987	-10.49	-0.44	-5.04	-4.67
1988	10.90	-5.31	-4.40	0.68
1989	1.63	-3.41	-4.44	-1.10
1990	3.43	-4.23	-1.48	2.53
1991	0.20	-3.98	6.58	10.40
Average	3.00	-3.13	-1.17	1.67
St. Dev.	6.97	1.88	3.91	4.02

Note: VA_{it} is the double-deflated value added at plant i, L_{it} is the total amount of labor at plant i, $VL_t := \sum_i VA_{it} / \sum_i L_{it}$, $VL_{it} := VA_{it}/L_{it}$, $\overline{VL}_{it} := (VL_{it} + VL_{it-1})/2$, $s_{it} := L_{it} / \sum_i L_{it}$,, $\bar{s}_{it} := (s_{it} + s_{it-1})/2$, and Δ is first-difference operator. The results exclude entry and exit.