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Explaining Reallocation's Apparent Negative Contribution to Growth[*]

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Abstract

We explain a puzzle from two recent meta-analyses that cover 25 countries and claim to show that inputs systematically move from higher-value to lower-value activities despite strong aggregate labor productivity growth (ALP). These papers use variants of the Baily, Hulten and Campbell (1992) decomposition of ALP to show that the reallocation covariance term is negative in all but two countries and the reallocation between term is negative in nine countries and weakly positive in most others. We decompose ALP using three micro-level data sets from Chile, Colombia, and Slovenia and show the same puzzle holds. We show that the ALP between term can be decomposed into a term related to reallocation and a term related to the change in the total number of fims, the latter of which often works to reduce the total between term in our data. We also show these ALP patterns can arise because of heterogeneity in labor and capital, unobserved output prices, or capacity utilization, but controlling for them only marginally helps to explain away the ALP reallocation puzzles in our micro-level data sets. We show that there is no puzzle when one decomposes aggregate productivity growth in the terms of National Accounts, as inputs in the aggregate move from low to high value activities in 36 of our 39 country-year observations. We conclude that there is a fundamental difference in reallocation measured by the ALP decomposition and that measured by the decomposition of National Accounts growth.

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1 Introduction

Theory shows that aggregate productivity growth can increase with no change in establishment-level technical efficiencies if resources move from lower- to higher-valued activities. Recent work by Hsieh and Klenow (2009) and Petrin and Sivadasan (2011) suggest that the gaps for inputs between their value of marginal product and their input price can be quite large due to barriers that prevent the free mobility of inputs.[1] Policy reforms that have been taking place throughout the world in recent history have in large part been aimed at stimulating growth by reducing barriers so resources like capital or labor can seek out higher marginal product activities.

In this paper we resolve the empirical puzzle related to reallocation that arises from the two recent meta-analyses. Bartelsman, Haltiwanger, and Scarpetta (2004) (BHS) decompose Aggregate Labor Productivity (ALP) for 15 countries that include a mix of industrial countries, Central and Eastern European countries, and emerging economies in Latin America and East Asia. Pages, Pierre, and Scarpetta (2009) (PPS) do the same for 13 countries in Latin America and the Caribbean.[2] The latter paper uses the decomposition from Baily, Hulten, and Campbell (1992) (BHC) and the former uses the modified BHC decomposition from Foster, Haltiwanger, and Krizan (2001) (FHK). These decompositions include three terms, a "within" growth term which measures growth in firm-level value-added per laborer, a "between" growth term tracks movements in labor inputs across firms with differing value-added per laborers, and a "covariance" term that tracks the co-movement of labor shares and value-added per laborer. Researchers often associate these latter two terms with reallocation growth because they relate the movements in inputs to value-added per laborer.

The reallocation puzzle that comes out of the studies is as follows. Value-added per laborer at the firm level is increasing robustly across most of these countries in the time periods analyzed.[3] In the face of this strong growth twenty-three of the twenty-five countries

[1]See also the survey paper by Syverson (2011).

[2]The complete list from BHS is Argentina, Chile, Colombia, Estonia, Finland, France, Korea, Latvia, Netherlands, Portugal, Slovenia, Taiwan, UK, USA, and West Germany. The complete list from PPS is Venezuela, Nicaragua, Peru, Paraguay, Brazil, Mexico, El Salvador, Colombia, Panama, Costa Rica, Argentina, Dominican Republic, and Chile.

[3]See Figure 4.8 in PPS and Figure 9 in BHS.

have a covariance term that is negative. Of these twenty-five countries nine of them have negative between terms, so one-third of the countries have negative overall reallocation, that is, one-third of these countries - including the United States from 1987 to 1997 - have inputs systematically reallocating from high-value to low-value activities. Most of the remaining countries with negative covariance have lackluster between growth especially when compared to the magnitude of their within term. There seems to be little reallocation from low-value to high-value activities despite deregulation and strong economic growth across almost all of these countries.

The unambiguous negative reallocation for the nine countries including the U.S. is particularly puzzling because theory models of allocative inefficiency do not have inputs reallocating from higher-value to lower-value activities. Instead in these models allocative inefficiency arises when barriers prevent inputs from moving to higher valued activities.[4] Either the theory models that we have on growth do not completely characterize what is happening with reallocation in the real world, or the definition of reallocation that comes out of the BHC/FHK decompositions is not measuring the reallocation about which the theory models are written. Our empirical findings suggest that the BHC/FHK reallocation terms do not measure growth from the perspective of theory models or national accounts.

We focus our investigation on Chile, Colombia, and Slovenia, three countries on which we have detailed micro-level data and that went through stark periods of deregulation prior to or during our sample periods. We show that the findings of BHS and PPS hold in our data, as strong within growth is coupled with a negative covariance term in all 40 country-year pairs in our data. For Chile and Colombia we also find weak between growth over the time period.

We start by checking whether a definition of reallocation that aligns more closely with the theory literature and national accounts practices on growth measurement also shows that inputs appear to be reallocating from more to less valuable activities. If we define aggregate productivity growth as the change in aggregate value added minus the change in expenditures on labor and capital then aggregate reallocation increases if an input moves from a firm where

[4] 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 (2008).

it has a low *value of marginal product-input cost* gap to one where it has a higher gap (see Petrin and Levinsohn (2011)).[5] This definition differs from BHC/FHK reallocation although it may be in the spirit of what the BHC/FHK reallocation terms are trying to capture.

Our findings using this new definition of reallocation are in sharp contrast to BHC/FHK. In our three data sets aggregate reallocation is *larger* in magnitude relative to the "within" growth term in all three countries, and it is positive in 36 of our 40 country-year pairs. While this does not explain away the ALP puzzles, it does suggest that these puzzles are an artifact of the BHC/FHK ALP decomposition.

We return to the question of why the BHC/FHK definition of reallocation appears to show weak or negative reallocation growth for our three countries. We show that the ALP between term can be decomposed into a term related to reallocation and a term related to the change in the total number of firms, the latter of which often works to reduce the total between term in our data. In Chile and Colombia separating out the number of firms term leads to a small but positive increase in between reallocation while in Slovenia it leads to a dramatic increase in between reallocation.

We then try to explain the negative covariance term. We show that unobserved prices, unobserved heterogeneity in capital and labor levels, and unobserved levels of capacity utilization could all possibly explain the negative covariance puzzle. We control as best we can for all of these factors. Except for unobserved heterogeneity in capital and labor in Slovenia, none of these stories can explain why BHC/FHK lead to negative covariance terms in our data.

The paper is organized as follows. Section 2 discusses aggregate labor productivity, its decomposition, and the puzzle. Section 3 describes our data and Section 4 shows the same puzzles exist. Section 5 shows there is no puzzle if the definition of aggregate reallocation is revised to more closely reflect what theory and national accounts define as reallocation. Section 6 explores the weak BHC/FHK between term, Section 7 looks at the covariance term, and Section 8 concludes.

[5] Under Petrin and Levinsohn (2011) the aggregation of establishment-level changes of technical efficiency and input reallocations add up to changes in aggregate value added, holding primary input use constant. Applications include Petrin, White, and Reiter (2011), Cubas et al. (2011), and Kwon et al. (2009).

2 The Reallocation Puzzle for Aggregate Labor Productivity

We develop the continuous time version of ALP and several discrete time approximations to it and then in Section 2.2 describe the empirical puzzles raised in Bartelsman et al (2004) and Pages, Pierre, and Scarpetta (2009) and elsewhere in the literature.

2.1 Continuous Time ALP and Discrete Time Approximations

We denote the amount of labor input and value added of establishment i at time t by L_{it} and VA_{it} respectively. Aggregate labor productivity (ALP) at time t - VL_t - is then given as

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

Researchers use the growth rate of the ratio of aggregate value added to aggregate labor as an indicator of changes in an economy's standard of living because of its link to changes in per capita income.

The source of the puzzle come from the decomposition of ALP into real productivity growth and reallocation components. VL_t can be re-expressed as

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

where $VL_{it} = \frac{VA_{it}}{L_{it}}$ is value added per laborer, $L_t = \sum_i L_{it}$ is aggregate labor input in the economy, $s_{it} = \frac{Lit}{L_t}$ is the employment share of establishment i at time t. In continuous time, 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 establishment-level changes in value added, and is typically referred to as the real productivity growth term. The second term is the sum of changes in employment share times the establishment-level value added per laborer and is referred to as the reallocation term. Researchers often compare these terms to understand their relative role in ALP growth.

We must use discrete time approximations to continuous time growth to estimate reallocation terms. We employ the two most popular approximations from Baily, Hulten, and Campbell (1992) and Foster, Haltiwanger, and Krizan (2001). These approximations add up to

$$\frac{VL_t - VL_{t-1}}{VL_{t-1}} \tag{2}$$

but differ in the ways they decompose the numerator $A \equiv VL_t - VL_{t-1}$.

Baily, Hulten, and Campbell (1992) decompose A as

$$A_1 \equiv \underbrace{\sum_{i\in\mathbf{C}} s_{it-1} * \Delta VL_{it}}_{\text{Within effect, weight } t-1} + \underbrace{\sum_{i\in\mathbf{C}} VL_{it} * \Delta s_{it}}_{\text{BHC between effect, weight } t} + \underbrace{\sum_{i\in\mathbf{E}} s_{it} * VL_{it}}_{\text{BHC Entry}} - \underbrace{\sum_{i\in\mathbf{X}} s_{it-1} * VL_{it-1}}_{\text{BHC Exit}},$$

where $\Delta VL_{it} = VL_{it} - VL_{it-1}$, $\Delta s_{it} = s_{it} - s_{it-1}$, and $\mathbf{C}$, $\mathbf{E}$, and $\mathbf{X}$ denote the set of continuing, entering, and exiting establishments at time t. The first two terms reflect the productivity growth of continuing establishments, and the last two terms reflect productivity growth due to turnover.[6]

The most commonly used form of this BHC decomposition rearranges the between term in A_1 and breaks out the cross term or the so-called "covariance":

$$\begin{aligned} A_2 \equiv\ & \underbrace{\sum_{i\in\mathbf{C}} s_{it-1} * \Delta VL_{it}}_{\text{Within effect, weight } t-1} + \underbrace{\sum_{i\in\mathbf{C}} VL_{it-1} * \Delta s_{it}}_{\text{BHC between effect, weight } t-1} + \underbrace{\sum_{i\in\mathbf{C}} \Delta VL_{it} * \Delta s_{it}}_{\text{Cross term}} \\ & + \underbrace{\sum_{i\in\mathbf{E}} s_{it} * VL_{it} - \sum_{i\in\mathbf{X}} s_{it-1} * VL_{it-1}}_{\text{BHC Net Entry}}. \end{aligned} \tag{3}$$

This between term contributes positively to the aggregate productivity when the market share of more productive establishments at time $t-1$ grows and the share of less productive

[6] Using the different periods of weights, we can construct the sum of the within and between terms in several ways. For instance, we can decompose $VL_{it} - VL_{it-1}$ into $\sum_i \frac{s_{it}+s_{it-1}}{2} \Delta VL_{it} + \sum_i \frac{VL_{it}+VL_{it-1}}{2} \Delta s_{it}$ (Tornquist approximation) or $\sum_i s_{it} \Delta VL_{it} + \sum_i VL_{it-1} \Delta s_{it}$.

establishments decreases. The covariance term contributes positively when those plants whose activities are becoming more valuable in terms of output per worker are also the plants that have relative increases in the share of labor. We follow Pages, Pierre, and Scarpetta (2009) and most of the literature and use decomposition A_2 in equation (3) as our BHC decomposition.[7]

The second approximation to $VL_t - VL_{t-1}$ comes from the decomposition measure used in Foster, Haltiwanger, and Krizan (2001). It decomposes the same object, $VL_t - VL_{t-1}$, into

$$\begin{aligned} A_3 \equiv & \underbrace{\sum_{i \in \mathbf{C}} s_{it-1} * \Delta VL_{it}}_{\text{Within effect, weight } t-1} + \underbrace{\sum_{i \in \mathbf{C}} (VL_{it-1} - VL_{t-1}) * \Delta s_{it}}_{\text{FHK Between effect, weight } t-1} + \underbrace{\sum_{i \in \mathbf{C}} \Delta VL_{it} * \Delta s_{it}}_{\text{Cross term}} \\ & \underbrace{+ \sum_{i \in \mathbf{E}} s_{it} * (VL_{it} - VL_{t-1}) - \sum_{i \in \mathbf{X}} s_{it-1} * (VL_{it-1} - VL_{t-1}).}_{\text{FHK Net Entry}} \end{aligned} \tag{4}$$

We employ decomposition A_3 in equation (4) as our FHK decomposition. The FHK between term is positive if establishments with above-average productivity increase their shares s_{it}. Similarly, entering establishments contribute positively to the aggregate productivity only if the establishment-level productivity is above the weighted industry average. In comparison to the BHC reallocation and net entry terms, by construction when the FHK between term is larger than the BHC between term, the BHC net entry term is larger than the FHK net entry term by the same magnitude. The within term and the covariance term are identical to the BHC decomposition in equation (3).[8]

2.2 The Puzzle

Pages, Pierre, and Scarpetta (2009) look at 13 countries in Latin America and the Caribbean, including Chile and Colombia. They report that the BHC between effect is positive but strikingly weak compared to the growth in aggregate labor productivity. Almost all of the growth in ALP is coming from the BHC within term, that is, from plants improving at

[7]Unlike Pages, Pierre, and Scarpetta (2009) our decomposition includes entrants and exiters. The only difference in the definitions when one includes entrants and exiters is in the calculation of aggregate ALP growth, from which net entry is now deducted.

[8]We have publicly available programs for computing aggregate productivity growth and its decomposition on Nishida's website.

producing more value-added per labor input, and not from labor inputs reallocating to higher value-added per labor plants. Furthermore, the authors also report that a "more worrisome element" is that the BHC covariance term is negative in all 13 countries in the report.

In terms of the FHK decomposition, the within and covariance results hold because the FHK within and covariance terms are identical to the BHC within and covariance term. We also know that if the FHK between term were more positive in this data, then the FHK net entry term would become more negative by the same magnitude. Thus if one thinks of net entry as a form of reallocation we know both empirical puzzles exist for either the BHC or the FHK decompositions of the numerator A.

These findings are particularly puzzling when one considers that theoretical models of reallocation almost universally have labor inputs either moving in the direction of more valuable activities or being stymied from moving in that direction. To our knowledge there are no theoretical models where inputs in the aggregate systematically move from the most valuable to the least valuable activities in the economy. Furthermore, the data comes from a period that has largely been one of deregulation of input and output markets, which should generally lead to a more fluid movement of inputs from lower-valued to higher-valued activities. We will focus on trying to understand why the between term is so weak and the covariance term is universally negative for these decompositions at a time when economic growth in the region is otherwise reasonably strong.

3 Data

This section describes our manufacturing data from Chile, Colombia, and Slovenia. Researchers interested in empirical results can skip directly to Section 4.

Chilean and Colombian Manufacturing Data The Chilean and Colombian data are annual and span the periods of 1979-95 and 1977-91, respectively. Here we provide a brief overview of these data. Numerous other productivity studies use them, and we refer interested readers to those papers for a more detailed data description.[9]

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 1977-82 and the plants with at least 10 employees for the years 1983-91. 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. 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.[10] We use double-deflated value added for Chilean results and single-deflated value added for Colombia because intermediate input deflators are not available there.[11]

Slovenian Manufacturing Data For Slovenian data, we use the annual accounting data provided by the Slovenian Statistical Office and other sources from 1994 through 2004. Our data are an unbalanced panel and covers all manufacturing firms.[12] We use single-deflated value added because no intermediate input deflator is available. The Slovenian data are distinct from Chilean and Colombian data in that a firm-level deflator and a capacity utilization rate can be obtained for a subset of firms.

As an ex-socialist country Slovenia went through extensive changes in its economic system starting in 1988. The deregulation of entry in 1988 allowed the setup of privately owned firms and resulted in expansion of private businesses. In addition, price and wage liberalization

[9] 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.

[10] 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 has a depreciation rate of 5%, 10%, and 20%, respectively. Some plants don't report initial capital stock, 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.

[11] See Appendix C for the details of the construction of double-deflated value-added.

[12] In Appendix A-1, we discuss how we construct the Slovenian data set from four distinct sources.

took place during the period of 1987-93. The process of privatization of state-owned firms started in 1994 and continued throughout the 1990s. For this reason, several empirical studies of productivity dynamics have used Slovenian data.[13]

4 The Puzzles in Chile, Colombia, and Slovenia

In this section we show the same puzzles raised elsewhere exist for our manufacturing data from Chile, Colombia, and Slovenia. Table 1 documents these facts for Chile. The second column in Table 1 is the annualized growth rate of aggregate value added and the third column is the growth rate of aggregate labor productivity. Most of the Pinochet market-based reforms were put into place by 1980 and aggregate value added increased on average by 4.16% over the sample period. While ALP increased by somewhat less over the entire sample period - 0.73% per year - if one focuses on the more recent history of 1988 to 1995 ALP is over 3% per year.

Columns 4 through 9 in Table 1 report the BHC and FHK decomposition of ALP into its real productivity growth, reallocation of employment for continuing establishments, and entry and exit components. For BHC columns 4 and 5 show that within firm growth of aggregate labor productivity clearly dominates the between reallocation term as it is over 10 times the magnitude on average (3.42% vs. 0.26%). In seven of the sixteen years aggregate between reallocation is negative. If one thinks of net entry as a form of reallocation related to the non-continuing firms, Column 8 shows stronger growth from net entry at on average 0.90%, but still less than a third of the growth coming from the within term.

Columns 6 and 9 are between and net entry for the FHK decomposition, the between is at 1.04% but reallocation from net entry falls to 0.12%. In six of the sixteen years aggregate between reallocation is negative. Since the FHK ALP exactly equals BHC ALP but differs in the the definition of the between term and the net entry term, the sum of these two terms for both decompositions is identical and equal to 1.16%. For Chile regardless of how we divide up these components we still find weak growth from between reallocation and net entry relative

[13] See, for example, Konings and de Loecker (2006), Polanec (2006), and Bartelsman, Haltiwanger, and Scarpetta (2010).

to within for the post-Pinochet reform period when we might expect to find much stronger growth from improvements in allocative efficiency.

More striking is the cross term in column 7. The contribution of the cross-term to the aggregate labor productivity is negative in every year and the mean of the contribution over time is −3.86% which is larger than the average positive contribution from the within growth term. Employment shares appear to move in the direction of the firms that have lower value added per laborer in Chile in the midst of strong economic growth.

Table 2 presents the results from Colombia over a similar time period. They largely echo the findings from Chile. Between 1978 and 1991 value added and ALP on average 4.28% and 3.94% per year respectively. The BHC and FHK between term's average contribution to the aggregate labor productivity is 1.10% and 1.34% when the within term's average contribution is 6.04%. The covariance term is again negative in every year and the sample average is −3.44%.

Table 3 shows that over the 1995 to 2004 Slovenia records even stronger growth than both Chile and Colombia. Value added and ALP increase on average 7.00% and 6.53% respectively. Compared with the within-term contribution to the aggregate labor productivity, contribution of the between reallocation term is stronger in Slovenia than in Chile and Colombia but it still makes a smaller contribution to the ALP than the within term (3.34% BHC vs. 4.96% within). The covariance term is again negative in every year and contributes on average −2.65% to growth. These results are puzzling because the theory models have losses from allocative inefficiencies that arise because barriers prevent inputs from moving in the right direction, but no theory models on reallocation have inputs systematically moving in the wrong direction.

5 Reallocation in Aggregate Productivity Growth

In this section we start with a definition of aggregate productivity growth (APG) closer to the approach used in national accounts. If we let APG equal the change in aggregate value added minus the change in expenditures on labor and capital, then aggregate reallocation increases if an input moves from a firm where it has a low *value of marginal product-input* *cost* gap to one where it has a higher gap (see Petrin and Levinsohn (2011)). We find that under this definition of reallocation - which is the definition that lines up with theoretical models of growth - aggregate reallocation is on average larger in magnitude relative to the "within" APG term in all three countries and it is positive in 36 of our 40 country-year pairs. While this does not explain away the ALP reallocation puzzle, it does suggest that it may be an artifact of the decomposition, and we return to that investigation in Section 6 and 7.

In growth rates APG by this definition can be expressed as the weighted sum of plant-level growth rates in value added minus the plant-level growth rates in primary inputs and is given as

$$APG = \sum_i D_i^v dlnVA_i - \sum_i \sum_k s_{ik} dlnX_{ik}, \quad (5)$$

with $D_i^v = \frac{VA_i}{\sum_i VA_i}$(the Domar weight) and the cost share for the kth primary input given as $s_{ik} = \frac{W_{ik}X_{ik}}{\sum_i VA_i}$ (with W_{ik} denoting input k's price and X_{ik} denoting its level). The final term deducts changes in the cost of primary inputs to account for the use of more or fewer inputs in production.

APG can be decomposed as

$$\underbrace{\sum_i D_i^v \sum_k (\varepsilon_{ik}^v - s_{ik}) dlnX_{ik}}_{\text{Reallocation of Labor and Capital}} + \underbrace{\sum_i D_i^v \sum_j (\varepsilon_{ij}^v - s_{ij}) dlnM_{ij}}_{\text{Reallocation of Materials}} + \underbrace{\sum_i D_i^v dln\omega_i^v}_{\text{Technical Efficiency}} - \underbrace{\sum_i D_i^v dlnF_i^v}_{\text{Fixed and Sunk Costs}}, \quad (6)$$

where the elasticities ε_{ik}^v are those for the value-added production function. Aggregate growth arising from the reallocation of primary inputs is given by $\sum_i D_i^v \sum_k (\varepsilon_{ik}^v - s_{ik}) dlnX_{ik}$ and growth from aggregate technical efficiency - the analog to the within term from ALP - is given by $\sum_i D_i^v dln\omega_i^v$.[14] If we rewrite the first two terms of this decomposition in levels we can more clearly see have the relationship between the value of marginal product - input price gaps to

[14] $dlnF^v$ denotes the costs associated with fixed and sunk costs and can be calculated as the residual of APG and the reallocation and technical efficiency terms. This last term can be calculated directly from our results but is not the focus of this paper.

aggregate reallocation for APG:

$$\sum_i \sum_k (P_i \frac{\partial Q_i}{\partial X_{ik}} - W_{ik}) dX_{ik} + \sum_i \sum_j (P_i \frac{\partial Q_i}{\partial M_{ij}} - P_j) dM_{ij}, \tag{7}$$

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, and dM_{ij} is the change in intermediate input j at establishment i. 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 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 value of the marginal product and the marginal cost, the reallocation of inputs from low gap activities to high gap activities increases APG without increasing the total use of inputs.

Equation (5) can be estimated directly from the discrete data using Tornquist-Divisia approximations.[15] For equation (6) we posit a value-added production function as

$$ln(VA_i) = \sum_k \varepsilon^v_{ik} lnX_{ik} + ln\omega^v_i, \tag{8}$$

with X_{ik} denoting the vector of primary inputs and ε^v_{ik} denoting the elasticity of (value-added) output with respect to the primary inputs.[16] We estimate production function parameters separately for each SIC 3-digit industry code for Chile and Colombia and NACE 2-digit industry code for Slovenia using the proxy method from Wooldridge (2009) that modifies Levinsohn and Petrin (2003) to address the simultaneous determination of inputs and productivity.[17]

[15] We chain-weight to update prices on an annual basis (they are included in the Domar weights). For example, $APG = \sum_i \overline{D}^v_{it} \Delta lnVA_{it} - \sum_i \overline{D^v}_{it} \sum_k \overline{s}^v_{ikt} \Delta lnX_{ikt}$ where $\overline{D}^v_{it}$ is the average of plant i's value-added share weights from period $t-1$ to period t, Δ is the first difference operator from period $t-1$ to period t, $\overline{s}_{ikt}$ is the average across the two periods of plant i's expenditures for the kth primary input as a share of plant-level value-added.

[16] We use three primary inputs as regressors: production (blue-collar) workers L^P_{it}, non-production (white-collar) workers L^{NP}_{it}, and capital K_{it} and aggregate the two labor inputs in our reallocation results.

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

The estimate of establishment-level technical efficiency is then

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

where $\widehat{\epsilon^v}_{j\cdot}$ denote the estimated elasticities of value added with respect to the inputs in industry j. We use Tornquist-Divisia approximations for each term in equation (6).[18]

Table 4 shows the aggregate reallocation and within growth terms under this "national accounts" definition of APG for Chile. The contribution of aggregate reallocation is positive for thirteen of the sixteen years and it accounts on average for 1.60% of APG, which averages 3.40% over this time period. If we break out labor reallocation's component to total reallocation it to is positive in eleven of the sixteen years and it accounts for almost half of the growth arising from reallocation. Table A1 shows reallocation growth plays an even bigger role in Colombia, where the average contribution of reallocation to APG is 3.63%. There is also only one of the fourteen years in which aggregate reallocation is negative and the contribution of labor reallocation is positive in ten of the fourteen years. Table 5 reports the results for Slovenia, where aggregate reallocation contributed on average 3.42% to an average APG of 5.17%. Aggregate reallocation is positive in every year of the sample as is the contribution of labor reallocation. The reallocation puzzle raised by the decomposition of ALP does not arise at all in this decomposition of APG, suggesting that the definition of ALP reallocation can be misleading if one's definition reallocation growth comes from decomposing a national accounts measure of economic growth.

6 Towards Explaining the Weak Between Term

In this section we show that the ALP between term can be decomposed into a term related to reallocation and a term related to the change in the total number of firms, the latter of which often works to reduce the total between term in our data. Letting N_t denote the number of firms in the economy, the average share of labor at a firm at time t is equal to $s_t = \frac{\sum s_{it}}{N_t} = \frac{1}{N_t}$,

[18] For the reallocation terms we use the approximations $\sum_i \overline{D}^v_{it} \sum_k (\varepsilon^v_{ik} - \overline{s}_{ikt})\Delta lnX_{ikt}$ and $\sum_i \overline{D}^v_{it} \sum_j (\varepsilon^v_{ij} - \overline{s}_{ijt})\Delta lnM_{ijt}$. For the within growth (technical efficiency) term we use $\sum_i \overline{D}^v_{it} \Delta ln\omega^v_{it}$.

the individual firm's relative share of labor is given as $\tilde{s}_{it} = s_{it} - s_t$, and the change in relative share from $t-1$ to t is $\Delta\tilde{s}_{it} = \tilde{s}_{it} - \tilde{s}_{i,t-1}$. The between term then decomposes as follows:

$$\begin{aligned}(BHC\ Between) &= \sum_{i\in\mathbf{C}_t} VL_{i,t-1}\Delta s_{it} \\ &= \sum_{i\in\mathbf{C}_t} VL_{i,t-1}\{(s_{it}-s_t)-(s_{it-1}-s_{t-1})\} + (s_t - s_{t-1})\sum_{i\in\mathbf{C}_t} VL_{i,t-1} \\ &= \underbrace{\sum_{i\in\mathbf{C_t}} \Delta\tilde{s}_{it} VL_{i,t-1}}_{\text{First component}} + \underbrace{(\frac{1}{N_t} - \frac{1}{N_{t-1}})\sum_{i\in\mathbf{C}_t} VL_{i,t-1}}_{\text{Second component}}, \qquad (9)\end{aligned}$$

where $\mathbf{C}_t$ is the set of continuing establishments at time t. The first component is positive when relative labor shares in the industry move in the direction of higher productivity firms. The second component is equal to the sum of value-added per labor across firms multiplied by $\frac{1}{N_t} - \frac{1}{N_{t-1}}$, a term that is unrelated to the reallocation of inputs from less valuable to more valuable activities. Because the sum of value-added per labor is always positive the second term confounds the first component in the negative direction when the number of firms increases and the positive direction when the number of firms decreases.

Table 6 presents the decomposition of the between term for Chile. Over the early period of the data when Chile is going through a recession there is a decrease in the number of firms and the second term confounds the first component in the positive direction. After the economy fully recovers and there is growth in the number of firms starting in 1987 the second component works to lower the overall between term. Comparing the first term to the overall BHC term we see that on average it is 0.44% higher over the sample period, that is, overall the second term has confounded between growth down. In Colombia the story is similar as the second term works to reduce the overall BHC term in eight of the fourteen years and the first component is on average 0.27% higher than the between term (see Table A2). Table 7 shows this confounding effect is most pronounced in Slovenia where the growth rate of firms is positive in every year. In every year the second component works to reduce measured reallocation, and over the entire sample period the average effect is −5.80%. Overall, separating this component out changes the reallocation message substantially in one country and to a smaller degree in the other two.

Before turning to the covariance term we note that the only difference between the FHK decomposition and the BHC decomposition is in its treatment of this second component and the net entry component. FHK does separate out the first component, but it then confounds the net entry reallocation term by adding the second component to it. One can see this in Table 1 as the FHK between term relative to BHC is 1.04% vs. 0.26% but the net entry term for FHK is 0.16% relative to the BHC term of 0.94%. As noted earlier the sum of these two terms must be equal because BHC ALP and FHK ALP are equal, and it is not clear why we want to confound net entry reallocation with this second component.

7 Towards Explaining the Negative Covariance Term

In this section we explore whether controlling for unobserved prices, for heterogeneity in capital and labor levels, and for unobserved capacity utilization can explain away the negative covariance term that appears in every year in every country.

7.1 Controlling for Unobserved Prices

The estimated productivity residual is affected by the fact that the typical measure of gross output used in establishment-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:

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

In terms of estimated growth rates, the size of the price measurement error added to VL_{it} is $\ln P_{it} - \ln P_t - (\ln P_{it-1} - \ln P_{t-1}) = \Delta \ln P_{it} - \Delta \ln P_t$. A negative covariance between employment share and VL_{it} could be caused by increasing quantities and decreasing prices, that is, a movement down the demand curve for the firm's products as the firm increases output and decreases prices to sell that extra output. If labor inputs increase to increase output, then labor share might increase when VL_{it} falls.

We use the Slovenian data to explore this possibility. 24% of the observations in the Slovenian data are on establishments for which product-specific quantities and revenues are collected. We use these quantities to construct unit prices for each of the establishment's products and then use the quantity-weighted average of these prices as the firm-level price deflator. We then return to the original data and replace the industry-level output deflator with the firm-level output deflator for these 24% of observations. We then recalculate the BHC and FHK decompositions on the full sample which has been partially corrected for the price measurement error.[19][20]

Table 8 presents the results of aggregate labor productivity decomposition by the BHC and FHK using the new sample. If the measurement error in price is indeed a cause of the negative covariance puzzle, we should expect the level of covariance to be higher when we use the sample with the mix of a firm-level deflator and an industry-level deflator. Column 7 in Table 8 shows that the covariance is virtually unchanged from the uncorrected results in Table 3. While the information on prices is limited to only one-quarter of the sample, the results are suggestive that the price measurement error story is not the cause of the negative covariance term.

7.2 Controlling for Capital and Labor Heterogeneity

If firms are substituting capital for labor then firms with increasing ALP - because they are increasing capital and reducing labor - are also firms that are reducing their labor share. To see whether this story holds in the data we return to the estimates of the value-added production function from Section 5 and use the estimates $\widehat{\ln \omega}_{it}^{v}$ as the measure of firm-level productivity. This measure controls for heterogeneity in both capital levels and for two types of labor. The multi-factor measure of aggregate productivity and its growth rate are given as

$$\begin{aligned} \ln \omega_t^v &= \sum_i s_{it} \widehat{\ln \omega}_{it}^{v} \\ \Delta \ln \omega_t^v &= \ln \omega_t^v - \ln \omega_{t-1}^v. \end{aligned}$$

[19] We use the full sample so results are comparable to Table 3.

[20] Our attempt is related to Foster, Haltiwanger, and Syverson (2008) in that both employ a plant-level price information. We do not, however, take their route- i.e., deriving physical productivity and estimating the level of idiosyncratic demand at the plant level- due to the severe limitation in the number of observations in our sample.

Table 9 presents the results for Chile. Conditioning on different labor types and capital causes the average BHC between term to change from being slightly positive (in Table 1) to -6.24%. The covariance terms remain negative in all years but two. Table A3 presents the results for Colombia and the findings are largely the same as the positive but weak between term becomes mostly negative and every covariance term remains negative. In contrast, the results from Table 10 for Slovenia do change. The BHC between turn increases and the covariance terms become positive for every year except one. Distinguishing between value-added per laborer and multi-factor productivity growth can change the covariance term and increase the between term relative to ALP but apparently is not the general source of the problem.

7.3 Controlling for Capacity Utilization

Let capacity utilization be denoted as $util_{it}$, so that the true capital input is $\ln(K_{it} * util_{it}) = \ln K_{it} + \ln util_{it}$,, where K_{it} is the observed capital input. Increases in unobserved capacity utilization appear as an increase in technical efficiency in the value-added production function:

$$\Delta\widehat{\ln\omega}_{it}^{v} = \Delta \ln \omega_{it}^{v} + \varepsilon_{iK}^{v} \Delta util_{it}.$$

If unobserved capital utilization were negatively correlated with labor, it could generate the negative covariance. For example, within-establishment substitution between hiring new bodies and increasing utilization rates could lead to a negative covariance term.

A separate survey for the Slovenian data is collected and it asks about utilization. This allows us to correct 11% of the observations in the Slovenian data for unobserved utilization. Once the capital terms have been corrected for this subset, these observations are added back to the full Slovenian data set. We compare these results to the multi-factor productivity results from Table A4 and find that the results are virtually unchanged. While the sample of firms for which we can correct for utilization is a small fraction of the total firms, unobserved capacity appears to not affect either the between terms or the covariance terms.

8 Conclusions

Despite deregulation in many of the 25 countries analyzed in Bartelsman, Haltiwanger, and Scarpetta (2004) and Pages, Pierre, and Scarpetta (2009) aggregate labor productivity growth for continuing establishments is weak or negative for most of these countries. This empirical finding runs counter to theoretical models of aggregate productivity growth based on reallocation where inputs move from lower-value to higher-value activities as the economy evolves over time.

We resolve this puzzle for Chile, Colombia, and Slovenia, three countries on which we have micro-level data. We show that the findings of BHS and PPS exist in these three data sets as inputs move in the direction of the lower productivity growth firms from the perspective of the traditional BHC/FHK decomposition of ALP. By redefining aggregate productivity growth and its decomposition in terms of its impact on aggregate final demand, we find aggregate input reallocation contributes positively to economic growth in thirty-seven of the forty country-year pairs that we observe, and the contribution to growth in on average equal to or greater than the contribution of within-firm productivity growth in every country. While this does not explain away the ALP puzzles, it does suggest that these puzzles are an artifact of the BHC/FHK ALP decomposition.

We then revisit the question of why the BHC/FHK definition of reallocation seems to exhibit weak or negative reallocation growth for our three countries. We show that the ALP between term contains a term that is closely related to the change in the total number of firms, which often works to reduce the total between term in our data. We also try to explain away the negative covariance term by controlling for unobserved prices, unobserved heterogeneity in capital and labor levels, and unobserved levels of capacity utilization. Except for unobserved heterogeneity in capital and labor in Slovenia, none of these stories can explain why BHC/FHK lead to negative covariance terms. The puzzle that does remain is what exactly does the BHC/FHK between and covariance terms measure in terms of the contribution of the reallocation of inputs to changes in aggregate final demand.

Appendix

A-1 Construction of Slovenian dataset

To construct the data set, we merge annual data sets from four distinct sources. The first source is the Agency of the Republic of Slovenia for Public Legal Records and Related Services (AJPES), which compiles the annual accounting data for all firms and for sole proprietors in manufacturing with at least 30 workers. The data set\ is comprised of firm-level data, although the accounting data are not consolidated. It is an unbalanced panel that includes a measure of nominal output, capital, and intermediate inputs. The second source is the Slovenian Statistical Office (SORS) that maintains the Slovenian Employment Registry (SER), which records employment durations of all workers in the economy and contains information on the employer's identity and employees' educational attainment, all of which are then used to determine the numbers of skilled and unskilled workers. The third source is the Slovenian Tax Office (TORS). The data contain information on annual labor income for each employee, which is used to calculate the annual cost of skilled and unskilled labor. The fourth data set is the industrial production (IP) survey of firms with at least 10 employees, performed annually by the SORS. It contains information on nominal output and physical quantities, disaggregated by products that are defined according to the 8-digit combined nomenclature (CN) product classification. From these, the prices of products are calculated and the price indices at the firm-level are constructed.

A-2 Construction of Firm-level Price Deflator

The firm-level price index is calculated using the annual industrial production (manufacturing and mining) survey for a set of Slovenian firms. The survey contains information on quantities and values sold by product, defined according to PRODCOM 8-digit code. The 2002-2009 provides information on non-response, which ranges between 9% and 15%. For example, in 2002, the number of surveyed establishments is $2,366$, out of which 12% (285) did not respond. Additional surveyed units are mis-classified; for example, a unit is classified as manufacturing or mining but performs other activities. We eliminated these units. For example, the address book contained 2,484 cases, of which 118 were mis-classified.

The data set is not a survey but should contain all establishments. The source of information is: http://www.stat.si/doc/metod_porocila/21_LPK_IND_L_2009.pdf

The product classifications used have changed over time. The SORS used a 9-digit national variety of NACE during 1989-1993, which distinguishes between 3,469 products. During 1994-2008, SORS used an 8-digit NACE, which distinguishes 5,666 product codes in 1994 and 1995; 5,622 product codes during 1996-2001; 5,153 during 2002-2003; 5,142 in 2004; etc. In 2004, a subset of 4,600 products were in manufacturing industries.

We use concordance files between different product classifications to create a time invariant product classification.

To calculate the firm-level price index, we have to deal with several issues. The ideal Fischer price index formula for firm i between periods $t-1$ and t is:

$$FPI_{it,t-1} = \sum_{j \in J_i} \overline{w}_{jit} \frac{p_{jit}}{p_{jit-1}},$$

where J_i is the set of output goods, $\overline{w}_{jit} = \frac{w_{jit}+w_{jit-1}}{2}$ and $w_{jit} = p_{jit}q_{jit}/\sum_{j \in J_i} p_{jit}q_{jit}$. Alternatively, one may use lagged or current weights. The Statistical Office uses lagged weights, as it does not possess the information on the revenue shares:

$$FPI_{it}^{lag} = \sum_{j \in J_i} w_{jit-1} \frac{p_{jit}}{p_{jit-1}}.$$

C Construction of Double-Deflated Value Added

Establishment i's price and quantity at time t are given by P_{it} and Q_{it}. As with most establishment-level data, we do not observe establishment-level prices, so we deflate establishment-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 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 use double-deflated value added for Chilean results. For Colombian and Slovenian results, since intermediate input deflators are not available, we use single-deflated value added using only the industry gross output price deflators P_{st}:

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

Finally, we use the consumer price index as a common deflator across all establishments 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.

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Table 1
Aggregate Labor Productivity (ALP) Growth Rate, Chilean Manufacturing 1980-95
BHC (1992) and FHK (2001) ALP Decomposition

Year	Value Added	(0) Labor Prod. Growth	BHC (1992) / FHK (2001) ALP Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1980	-3.28	-7.15	-5.18	2.57	2.26	-4.22	-0.31	0.00
1981	1.37	5.63	8.14	-0.55	0.06	-2.11	0.15	-0.46
1982	-21.76	-4.81	-9.44	8.04	3.76	-2.15	-1.27	3.01
1983	-0.27	-1.80	-0.12	1.11	-0.18	-2.13	-0.66	0.64
1984	9.94	2.90	10.02	-3.75	-2.07	-4.63	1.26	-0.42
1985	3.72	-4.01	-0.73	0.76	-0.05	-3.22	-0.82	-0.01
1986	8.43	1.19	6.61	-0.31	-2.03	-3.88	-1.23	0.49
1987	7.34	-5.54	-1.72	-4.31	-0.80	-3.22	3.70	0.20
1988	6.55	-1.81	0.61	-1.30	-0.85	-2.55	1.43	0.98
1989	11.02	0.64	4.40	-1.47	1.00	-4.35	2.07	-0.40
1990	3.74	2.57	7.01	0.14	1.25	-5.73	1.15	0.04
1991	7.03	3.28	6.50	1.20	4.79	-6.86	2.44	-1.14
1992	14.55	5.07	7.98	-3.22	0.86	-3.78	4.08	0.00
1993	5.58	4.21	7.41	1.39	3.06	-5.71	1.12	-0.55
1994	2.39	1.69	2.51	2.81	3.30	-3.64	0.01	-0.48
1995	10.19	9.61	10.79	0.97	2.30	-3.50	1.34	0.02
Average	4.16	0.73	3.42	0.26	1.04	-3.86	0.90	0.12
St. Dev.	8.28	4.60	5.74	2.96	2.06	1.38	1.63	0.93

Notes: Percentage growth rates. Labor productivity is defined as the ratio of value added over employment. "Value Added" is the growth rate of aggregate value added, which is constructed by summing the establishment-level double-deflated value added across establishments and then taking the annual growth rate. "Labor Productivity Growth" represents the aggregate labor productivity growth with entry and exit. Labor Productivity Growth is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using equation 3 in text for BHC (1992) and equation 4 in text for FHK (2001). We use employment share for the share weights. Both (1) within and (2) between terms use base-period share for the weights.

Table 2
Aggregate Labor Productivity (ALP) Growth Rate, Colombia Manufacturing 1978-91
BHC (1992) and FHK (2001) ALP Decomposition

Year	Value Added	(0) Labor Prod. Growth	BHC (1992) / FHK (2001) ALP Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1978	11.93	8.56	9.84	1.77	2.36	-4.17	1.13	0.54
1979	9.89	6.78	6.72	2.50	2.94	-2.84	0.41	-0.03
1980	6.92	6.55	7.14	0.94	1.75	-1.94	0.42	-0.40
1981	-10.11	-8.68	-6.56	1.49	2.26	-2.62	-1.00	-1.77
1982	0.30	2.47	3.95	1.99	3.11	-3.77	0.30	-0.82
1983	0.05	3.75	4.44	2.32	1.46	-2.78	-0.24	0.62
1984	6.69	8.58	8.32	1.95	1.26	-2.17	0.48	1.17
1985	7.35	10.85	17.18	1.12	-0.05	-7.17	-0.28	0.89
1986	10.76	0.91	5.83	-1.96	0.15	-3.74	0.77	-1.33
1987	-1.55	-1.80	2.63	-3.77	-1.45	-2.11	1.45	-0.87
1988	9.48	10.51	14.79	3.20	2.10	-7.88	0.40	1.50
1989	3.39	1.99	4.43	0.00	0.65	-2.67	0.23	-0.43
1990	4.55	3.95	4.08	1.93	1.62	-2.21	0.14	0.45
1991	0.26	0.78	1.75	1.95	0.61	-2.14	-0.78	0.57
Average	4.28	3.94	6.04	1.10	1.34	-3.44	0.24	0.01
St. Dev.	6.03	5.31	5.71	1.87	1.26	1.87	0.67	0.97

Notes: Percentage growth rates. Labor productivity is defined as the ratio of value added over employment. "Value Added" is the growth rate of aggregate value added, which is constructed by summing the establishment-level single-deflated value added across establishments and then taking the annual growth rate. "Labor Productivity Growth" represents the aggregate labor productivity growth with entry and exit. Labor Productivity Growth is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using equation 3 in text for BHC (1992) and equation 4 in text for FHK (2001). We use employment share for the share weights. Both (1) within and (2) between terms use base-period share for the weights.

Table 3
Aggregate Labor Productivity (ALP) Growth Rate, Slovenian Manufacturing 1995-2004
BHC (1992) and FHK (2001) ALP Decomposition
Industry-level Price Deflator

Year	Value Added	(0) Labor Prod. Growth	BHC (1992) / FHK (2001) ALP Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1995	4.01	5.51	-0.82	7.68	5.79	-4.92	3.58	5.47
1996	7.39	8.40	5.47	5.65	5.25	-3.61	0.89	1.29
1997	14.60	15.05	12.72	5.69	6.30	-5.74	2.37	1.76
1998	2.90	0.07	-1.98	4.53	4.90	-3.94	1.46	1.08
1999	8.35	6.56	7.21	-0.82	0.55	-0.84	1.00	-0.37
2000	8.27	6.42	6.00	1.78	1.23	-1.75	0.39	0.94
2001	4.28	4.25	3.98	2.38	1.57	-1.34	-0.77	0.05
2002	9.04	6.44	6.42	-0.75	1.32	-1.31	2.08	0.01
2003	6.54	8.09	6.80	4.54	2.57	-1.92	-1.34	0.64
2004	4.62	4.54	3.84	2.69	1.63	-1.13	-0.85	0.21
Average	7.00	6.53	4.96	3.34	3.11	-2.65	0.88	1.11
St. Dev.	3.41	3.81	4.16	2.80	2.19	1.75	1.57	1.67

Notes: Percentage growth rates. Labor productivity is defined as the ratio of value added over employment. "Value Added" is the growth rate of aggregate value added, which is constructed by summing the establishment-level single-deflated value added across establishments and then taking the annual growth rate. "Labor Productivity Growth" represents the aggregate labor productivity growth with entry and exit. Labor Productivity Growth is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using equation 3 in text for BHC (1992) and equation 4 in text for FHK (2001). We use a 2-digit industry-level price deflator to obtain deflated value added. We use employment share for the share weights. Both (1) within and (2) between terms use base-period share for the weights.

Table 4
Aggregate Multifactor Productivity Growth Rate, Chilean Manufacturing 1980-95
Petrin and Levinsohn (2011) Aggregate Productivity Growth (APG) Decomposition

Year	Value Added	(0) APG	APG Decomposition: (0) = (1) + (2) + (3)			
				Reallocation		
			(1) Technical Efficiency	(2) Total Reallocation	Labor Reallocation	(3) Net Entry
1980	-3.28	-5.18	-3.50	-0.31	-0.10	-1.37
1981	1.37	-3.61	1.43	0.65	-0.78	-5.70
1982	-21.76	-11.68	-16.47	-2.82	-2.20	7.62
1983	-0.27	3.81	-0.39	1.59	-0.59	2.60
1984	9.94	10.19	7.94	1.56	1.46	0.69
1985	3.72	5.65	3.29	0.64	1.57	1.71
1986	8.43	5.14	6.75	0.86	1.15	-2.47
1987	7.34	7.24	-3.88	3.22	1.53	7.90
1988	6.55	5.59	3.31	0.51	1.49	1.78
1989	11.02	8.53	0.96	6.22	2.41	1.35
1990	3.74	1.03	-0.56	2.42	1.26	-0.82
1991	7.03	3.76	1.68	2.19	1.60	-0.11
1992	14.55	10.61	6.66	2.28	1.79	1.67
1993	5.58	3.56	-0.75	4.34	1.52	-0.03
1994	2.39	0.06	-0.08	2.32	0.63	-2.18
1995	10.19	9.70	8.74	-0.01	-0.50	0.97
Average	4.16	3.40	0.95	1.60	0.76	0.85
St. Dev.	8.28	6.10	6.01	2.05	1.24	3.40

Notes: Percentage growth rates. To calculate the plant-level multifactor productivity, this table uses the production function parameter estimates we use in Table 2; production function parameters that vary across 3-digit ISIC are estimated using Wooldridge (2009). APG represents the aggregate productivity growth with entry and exit, which is defined as aggregate change in final demand, holding input constant. See equation 5 in text for detail. We use value-added share for weights. APG is decomposed into four components: (1) technical efficiency, (2) reallocation, and (3) net entry term, using equation 6 in text.

Table 5
Aggregate Multifactor Productivity Growth Rate, Slovenian Manufacturing 1995-2004
Petrin and Levinsohn (2011) Aggregate Productivity Growth (APG) Decomposition
Industry-level Price Deflator

Year	Value Added	(0) APG	APG Decomposition: (0) = (1) + (2) + (3)			
				Reallocation		
			(1) Technical Efficiency	(2) Total Reallocation	Labor Reallocation	(3) Net Entry
1995	4.01	2.68	-3.01	3.21	2.07	2.48
1996	7.39	5.95	3.70	2.41	1.72	-0.16
1997	14.60	12.60	5.00	6.83	1.32	0.77
1998	2.90	0.63	-3.95	4.47	1.91	0.11
1999	8.35	6.05	3.96	2.75	0.61	-0.66
2000	8.27	6.10	3.42	3.57	0.96	-0.90
2001	4.28	3.14	2.02	2.71	0.74	-1.58
2002	9.04	6.51	3.92	2.42	0.66	0.17
2003	6.54	4.81	4.24	3.19	0.61	-2.62
2004	4.62	3.22	2.35	2.67	0.86	-1.81
Average	7.00	5.17	2.17	3.42	1.15	-0.42
St. Dev.	3.41	3.23	3.11	1.35	0.57	1.45

Notes: Percentage growth rates. To calculate the plant-level multifactor productivity, this table uses the production function parameter estimates we use in Table 8; production function parameters that vary across 2-digit NACE are estimated using Wooldridge (2009). We use a 2-digit industry-level price deflator to obtain deflated value added. APG represents the aggregate productivity growth with entry and exit, which is defined as aggregate change in final demand, holding input constant. See equation 5 in text for detail. We use value-added share for weights. APG is decomposed into four components: (1) technical efficiency, (2) reallocation, and (3) net entry term, using equation 6 in text.

Table 6
Aggregate Labor Productivity (ALP) Growth Rate, Chilean Manufacturing 1980-95
BHC (1992) Between Term Decomposition

Year	BHC (0): Between Term	BHC (1992) Between Term Decomposition: (0) = (1) + (2)		Number of Firms
		(1): First component	(2) Second component	
1980	2.57	3.51	-0.95	1.76
1981	-0.55	-1.48	0.93	-1.84
1982	8.04	3.56	4.49	-7.96
1983	1.11	-2.23	3.34	-6.91
1984	-3.75	-2.70	-1.04	2.35
1985	0.76	0.11	0.64	-1.33
1986	-0.31	-1.99	1.68	-3.54
1987	-4.31	-0.83	-3.48	7.50
1988	-1.30	-1.38	0.08	-0.15
1989	-1.47	-0.12	-1.34	2.50
1990	0.14	2.32	-2.17	3.91
1991	1.20	4.18	-2.98	5.27
1992	-3.22	0.50	-3.72	6.60
1993	1.39	2.98	-1.60	2.69
1994	2.81	3.32	-0.51	0.85
1995	0.97	1.39	-0.42	0.70
Average	0.26	0.70	-0.44	0.78
St. Dev.	2.96	2.36	2.29	4.36

Notes: Percentage growth rates. BHC Between Term is decomposed into two terms using equation 9 in the text.

Table 7
Aggregate Labor Productivity (ALP) Growth Rate, Slovenian Manufacturing 1995-2004
BHC (1992) Between Term Decomposition

Year	BHC (0): Between Term	BHC (1992) Between Term Decomposition: (0) = (1) + (2) (1): First component	(2) Second component	Number of Firms
1995	7.68	27.33	-19.65	17.44
1996	5.65	15.61	-9.96	9.55
1997	5.69	12.73	-7.04	7.06
1998	4.53	10.80	-6.27	6.56
1999	-0.82	1.97	-2.79	2.90
2000	1.78	4.63	-2.85	2.97
2001	2.38	4.40	-2.02	2.13
2002	-0.75	3.67	-4.42	5.05
2003	4.54	6.01	-1.47	1.65
2004	2.69	4.26	-1.57	1.82
Average	3.34	9.14	-5.80	5.71
St. Dev.	2.80	7.79	5.59	4.89

Notes: Percentage growth rates. BHC Between Term is decomposed into two terms using equation 9 in the text.

Table 8
Aggregate Labor Productivity (ALP) Growth Rate, Slovenian Manufacturing 1995-2004
BHC (1992) and FHK (2001) ALP Decomposition
Firm-level and Industry-level Price Deflator

Year	Value Added	(0) Labor Prod. Growth	BHC (1992) / FHK (2001) ALP Decomposition: (0) = (1) + (2) + (3) + (4) (1) Within	(2) Between BHC	(2) Between FHK	(3) Cross	(4) Net Entry BHC	(4) Net Entry FHK
1995	7.20	9.96	3.19	8.78	5.89	-4.35	2.35	5.24
1996	4.32	7.59	2.83	7.35	4.93	-2.42	-0.18	2.24
1997	12.94	12.64	11.26	5.06	6.10	-5.86	2.18	1.14
1998	8.23	5.99	6.60	3.53	3.70	-4.25	0.11	-0.06
1999	10.27	7.36	7.22	-1.55	0.48	-1.03	2.72	0.69
2000	9.13	8.50	7.66	3.11	1.51	-1.63	-0.64	0.96
2001	4.77	4.57	7.39	1.84	1.45	-1.25	-3.40	-3.02
2002	9.78	8.32	8.01	-0.06	1.24	-1.40	1.78	0.48
2003	2.94	4.75	3.84	4.18	2.33	-1.85	-1.43	0.43
2004	7.63	9.87	5.13	3.94	1.13	-0.93	1.74	4.54
Average	7.72	7.96	6.31	3.62	2.88	-2.50	0.52	1.27
St. Dev.	3.05	2.50	2.60	3.10	2.11	1.71	1.98	2.34

Notes: The number of observations with an establishment-level price deflator accounts for 24% of the total number of observations. For these observations, we use an establishment-level price deflator to obtain deflated value added. Otherwise, we use a 2-digit industry-level price deflator to obtain deflated value added. See notes to Table 3 for the construction of the plant-level labor productivity, "Value Added," "Labor Prod. Growth," and share weights, and the decomposition of Labor Productivity Growth.

Table 9
Aggregate Multifactor Productivity Growth Rate, Chilean Manufacturing 1980-95
BHC (1992) and FHK (2001) Decomposition

Year	Value Added	(0) Multifactor Prod. Growth	BHC (1992) / FHK (2001) Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1980	-3.28	-19.86	-13.72	1.07	-1.45	0.04	-7.25	-4.73
1981	1.37	4.02	3.47	-9.38	-4.55	1.00	8.94	4.11
1982	-21.76	-11.33	-21.87	38.17	4.24	-1.17	-26.46	7.47
1983	-0.27	-3.46	-6.08	10.05	-0.06	-0.08	-7.36	2.75
1984	9.94	4.27	11.69	-19.51	-6.46	-0.41	12.49	-0.56
1985	3.72	-5.38	1.03	5.81	-0.50	-0.80	-11.43	-5.12
1986	8.43	8.12	9.54	12.06	-1.30	-3.01	-10.47	2.88
1987	7.34	-7.10	-3.87	-29.29	-1.78	-1.36	27.43	-0.09
1988	6.55	4.26	4.07	-3.71	-0.19	-0.13	4.03	0.51
1989	11.02	0.05	-0.50	-18.34	0.97	-2.22	21.11	1.80
1990	3.74	4.21	6.89	-7.78	0.90	-2.18	7.27	-1.41
1991	7.03	7.46	7.52	-24.90	3.32	-2.64	27.49	-0.73
1992	14.55	7.98	10.12	-33.14	-0.77	-1.41	32.41	0.04
1993	5.58	0.42	2.77	-11.30	2.06	-2.68	11.64	-1.73
1994	2.39	0.28	-1.08	-1.20	2.71	-0.89	3.45	-0.45
1995	10.19	5.54	4.07	-8.42	2.18	-1.73	11.61	1.01
Average	4.16	-0.03	0.88	-6.24	-0.04	-1.23	6.56	0.36
St. Dev.	8.28	7.75	8.93	17.84	2.80	1.14	16.23	3.12

Notes: Percentage growth rates. The plant-level multifactor productivity is calculated using production function parameters that vary across 3-digit ISIC estimates using Wooldridge (2009). "Value Added" is the growth rate of aggregate value added, which is constructed by summing the establishment-level double-deflated value added across establishments and then taking the annual growth rate. "Multifactor Prod. Growth" represents the aggregate multifactor productivity growth with entry and exit, which is the weighted sum of plant-level multifactor productivity across establishments. We use employment share for the share weights. Multifactor Prod. Growth is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using equation 3 in text for BHC (1992) and equation 4 in text for FHK (2001). Both (1) within and (2) between terms use base-period share for the weights.

Table 10
Aggregate Multifactor Productivity Growth Rate, Slovenian Manufacturing 1995-2004
BHC (1992) and FHK (2001) Decomposition
Industry-level Price Deflator

Year	Value Added	(0) Multifactor Prod. Growth	BHC (1992) / FHK (2001) Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1995	4.01	2.22	-1.85	33.57	1.94	-0.35	-29.15	2.48
1996	7.39	6.25	3.00	8.42	1.67	0.35	-5.52	1.23
1997	14.60	13.37	6.63	-8.80	1.46	0.31	15.23	4.97
1998	2.90	1.41	-2.09	-4.01	2.32	0.22	7.28	0.96
1999	8.35	2.10	2.96	-24.84	-1.59	1.34	22.64	-0.61
2000	8.27	4.70	3.13	9.76	0.44	0.69	-8.87	0.44
2001	4.28	4.10	2.46	14.95	1.10	0.27	-13.58	0.27
2002	9.04	5.30	3.40	-34.14	1.24	0.31	35.73	0.35
2003	6.54	3.76	1.79	34.40	0.55	1.08	-33.51	0.34
2004	4.62	3.12	1.76	19.85	1.55	0.16	-18.65	-0.35
Average	7.00	4.63	2.12	4.92	1.07	0.44	-2.84	1.01
St. Dev.	3.41	3.42	2.55	22.92	1.10	0.48	22.63	1.64

Notes: Percentage growth rates. The plant-level multifactor productivity is calculated using production function parameters that vary across 2-digit NACE estimates using Wooldridge (2009). "Value Added" is the growth rate of aggregate value added, which is constructed by summing the establishment-level single-deflated value added across establishments and then taking the annual growth rate. We use a 2-digit industry-level price deflator to obtain deflated value added. "Multifactor Prod. Growth" represents the aggregate multifactor productivity growth with entry and exit, which is the weighted sum of plant-level multifactor productivity across establishments. We use employment share for the share weights. Multifactor Prod. Growth is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using equation 3 in text for BHC (1992) and equation 4 in text for FHK (2001). Both (1) within and (2) between terms use base-period share for the weights.

Table A1
Aggregate Multifactor Productivity Growth Rate, Colombia Manufacturing 1978-91
Petrin and Levinsohn (2011) Aggregate Productivity Growth (APG) Decomposition

Year	Value Added	(0) APG	APG Decomposition: (0) = (1) + (2) + (3)			
				Reallocation		
			(1) Technical Efficiency	(2) Total Reallocation	Labor Reallocation	(3) Net Entry
1978	11.93	5.59	-1.11	9.79	2.76	-3.09
1979	9.89	9.03	-0.48	8.84	1.91	0.67
1980	6.92	5.85	2.87	3.25	1.14	-0.27
1981	-10.11	-11.19	-14.13	4.76	0.15	-1.83
1982	0.30	-2.44	-2.86	3.94	0.02	-3.53
1983	0.05	-0.98	-0.20	1.71	-1.05	-2.49
1984	6.69	6.45	4.76	2.10	-0.08	-0.42
1985	7.35	9.24	11.30	-2.05	-2.89	-0.01
1986	10.76	10.37	12.83	1.02	-0.34	-3.48
1987	-1.55	-1.83	-13.15	4.37	1.18	6.95
1988	9.48	9.56	5.58	3.56	1.44	0.41
1989	3.39	2.40	0.22	2.48	0.18	-0.30
1990	4.55	3.53	0.03	4.07	2.02	-0.57
1991	0.26	-0.50	-2.19	2.98	0.84	-1.29
Average	4.28	3.22	0.25	3.63	0.52	-0.66
St. Dev.	6.03	6.09	7.55	2.96	1.43	2.61

Notes: Percentage growth rates. To calculate the plant-level multifactor productivity, this table uses the production function parameter estimates we use in Table 5; production function parameters that vary across 3-digit ISIC are estimated using Wooldridge (2009). APG represents the aggregate productivity growth with entry and exit, which is defined as aggregate change in final demand, holding input constant. See equation 5 in text for detail. We use value-added share for weights. APG is decomposed into four components: (1) technical efficiency, (2) reallocation, and (3) net entry term, using equation 6 in text.

Table A2
Aggregate Labor Productivity (ALP) Growth Rate, Colombian Manufacturing 1978-91
BHC (1992) Between Term Decomposition

Year	BHC (0): Between Term	BHC (1992) Between Term Decomposition: (0) = (1) + (2)		Number of Firms
		(1): First component	(2) Second component	
1978	1.77	1.66	0.11	-0.22
1979	2.50	3.70	-1.20	2.25
1980	0.94	1.86	-0.93	1.84
1981	1.49	1.23	0.26	-0.48
1982	1.99	3.91	-1.91	3.84
1983	2.32	-3.39	5.71	-11.02
1984	1.95	2.03	-0.08	0.15
1985	1.12	-0.02	1.14	-2.20
1986	-1.96	1.94	-3.89	7.91
1987	-3.77	-1.54	-2.22	4.12
1988	3.20	4.43	-1.23	2.29
1989	0.00	2.04	-2.05	3.88
1990	1.93	1.46	0.47	-0.86
1991	1.95	-0.02	1.98	-3.61
Average	1.10	1.38	-0.27	0.56
St. Dev.	1.87	2.11	2.30	4.46

Notes: Percentage growth rates. BHC Between Term is decomposed into two terms using equation 9 in the text.

Table A3
Aggregate Multifactor Productivity Growth Rate, Colombia Manufacturing 1978-91
BHC (1992) and FHK (2001) Decomposition

Year	Value Added	(0) Multifactor Prod. Growth	BHC (1992) / FHK (2001) Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1978	11.93	0.69	2.83	-2.66	1.92	-3.12	3.64	-0.94
1979	9.89	0.93	0.96	-1.90	1.51	-2.06	3.94	0.52
1980	6.92	3.76	4.60	-6.00	0.33	-1.70	6.87	0.53
1981	-10.11	-13.53	-12.90	-4.68	1.33	-1.45	5.50	-0.51
1982	0.30	-2.92	-1.96	-7.83	0.72	-1.30	8.18	-0.38
1983	0.05	0.05	-0.79	7.18	0.55	-1.35	-4.99	1.64
1984	6.69	5.07	4.35	6.17	0.89	-1.44	-4.01	1.27
1985	7.35	2.74	3.80	9.10	0.09	-2.85	-7.32	1.69
1986	10.76	1.94	1.77	-16.11	0.14	-1.97	18.25	2.00
1987	-1.55	-10.26	1.22	-18.39	-0.47	-7.04	13.95	-3.97
1988	9.48	11.94	6.64	15.78	7.42	-8.63	-1.86	6.50
1989	3.39	2.11	1.91	-3.37	1.72	-1.93	5.49	0.40
1990	4.55	3.88	3.32	4.26	1.88	-1.59	-2.11	0.27
1991	0.26	2.09	0.28	12.13	1.61	-1.77	-8.55	1.97
Average	4.28	0.61	1.14	-0.45	1.40	-2.73	2.64	0.79
St. Dev.	6.03	6.27	4.64	10.09	1.89	2.25	7.89	2.26

Notes: Percentage growth rates. The plant-level multifactor productivity is calculated using production function parameters that vary across 3-digit ISIC estimates using Wooldridge (2009). "Value Added" is the growth rate of aggregate value added, which is constructed by summing the establishment-level single-deflated value added across establishments and then taking the annual growth rate. "Multifactor Prod. Growth" represents the aggregate multifactor productivity growth with entry and exit, which is the weighted sum of plant-level multifactor productivity across establishments. We use employment share for the share weights. Multifactor Prod. Growth is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using equation 3 in text for BHC (1992) and equation 4 in text for FHK (2001). Both (1) within and (2) between terms use base-period share for the weights.

Table A4
Aggregate Multifactor Productivity Growth Rate, Slovenian Manufacturing 1995-2004
BHC (1992) and FHK (2001) Decomposition
Industry-level Deflator, Capital Input Adjusted by Capacity Utilization Rate

Year	Value Added	(0) Multifactor Prod. Growth	BHC (1992) / FHK (2001) Decomposition: (0) = (1) + (2) + (3) + (4)					
			(1) Within	(2) Between		(3) Cross	(4) Net Entry	
				BHC	FHK BHC			FHK
1995	4.01	9.74	4.45	34.05	2.20	-0.39	-28.37	3.49
1996	7.39	7.48	4.22	8.06	1.23	0.38	-5.17	1.65
1997	14.60	11.84	6.36	-9.53	0.86	0.30	14.70	4.32
1998	2.90	1.09	-1.49	-4.86	1.54	0.16	7.28	0.88
1999	8.35	2.87	3.24	-25.34	-1.84	1.26	23.71	0.21
2000	8.27	4.42	2.80	9.75	0.33	0.72	-8.85	0.57
2001	4.28	4.44	3.39	15.24	1.22	0.28	-14.47	-0.45
2002	9.04	5.11	3.66	-35.12	0.66	0.25	36.32	0.55
2003	6.54	3.42	2.33	34.83	0.61	1.10	-34.84	-0.61
2004	4.62	3.85	1.93	20.07	1.58	0.15	-18.30	0.20
Average	7.00	5.43	3.09	4.72	0.84	0.42	-2.80	1.08
St. Dev.	3.41	3.30	2.03	23.42	1.09	0.48	22.95	1.63

Notes: We replace the capital input with the capital input multiplied by the capacity utilization rate whenever possible, and end up replacing 11% of the total number of observations. See notes to Table 8 for the construction of the plant-level multifactor productivity, "Value Added," "Multifactor Prod. Growth," and share weights, and the decomposition of Multifactor Productivity Growth.