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How tight is the link between wages and productivity? A survey of the literature

Johannes Van Biesebroeck

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How tight is the link between wages and productivity?

A survey of the literature

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Preface

Wage policies and labour market institutions play a crucial role in building equitable societies and sustainable economies, in which the fruits of progress are shared with all. Recent trends around the world reveal that in many countries wages have not grown as rapidly as labour productivity, leading to a decline in the share of national income paid out as labour compensation. A majority of countries have also experienced growing inequality in the personal distribution income - with incomes increasing much more rapidly at the top than in the middle or at the bottom of the distribution. Such trends can be harmful for social justice, and can lead to “internal imbalances”, inducing families to borrow beyond their means and exerting a downward pressure on household consumption and aggregate demand. In some instances, wages have increased more rapidly than labour productivity, eroding external competitiveness and sometimes discouraging investment. Unsurprisingly, therefore, wage policies today stand at the centre of policy-making, receiving close attention from governments and social partners who - within their own national context – seek to ensure that minimum wages, collective bargaining, and other labour market institutions contribute to fair, efficient and inclusive labour markets.

This working paper by Johannes Van Biesebroeck provides a review of the links between wages and productivity, based mainly on the mainstream economic literature (and hence best complemented with other more “heterodox” literature). This review was undertaken as part of a broader project seeking to document how wage and labour productivity growth are related to each other, and how productivity indicators can be used in the context of collective bargaining or for the purpose of minimum wage fixing. The paper seeks to provide some information to help our understanding of the growing disconnect between wages and productivity growth, in both developed and emerging economies. The theoretical arguments reviewed in the paper show that there are many reasons why wages and productivity may not “automatically” grow in tandem, in spite of the predictions of the standard neo-classical model, and that in a world of imperfect competition the division of the economic “surplus” depends on workers’ relative bargaining power. The review of the empirical literature shows that individual characteristics can indeed affect wages and productivity differently, with examples of women or young workers being under-remunerated even when they have similar productive characteristics as other groups. In the part of his paper devoted to measurement issues, Van Biesebroeck also reminds us that while individual productivity can be informative insofar as it is possible to identify the output of an individual worker, when there is some element of team production (which is the case in most occupations) it is impossible to calculate productivity at the individual level, and labour productivity is thus best analysed at the level of plants, firms, sectors, or countries.

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1. Introduction

Labor productivity is a widely used measure. It is defined as the value of output that a worker, a firm, an industry, or a country has produced per unit of labor input. To calculate labor productivity, one simply divides output by labor input. It can be measured in levels or in growth rates. Usually it is put in a comparative context, i.e. one firm is 5% more productive than another or productivity is 2% higher today than it was last year, but it also has an absolute interpretation. The output per worker that a group of workers has produced will be the total value available for consumption and also the maximum total income available to each worker. At an aggregate level, the total number of workers is the one exogenously given input for the economy. Other inputs, such as intermediates and capital, tend to be outputs of particular production processes in the economy. As such, over the long run labor productivity growth will measure the absolute output potential of an economy (Hulten, 1978).

Part A of this paper discusses issues of measurement. Measurement issues are extremely important to arrive at a concept that is comparable across different production units or over time. Both the unit of output and the unit of input can be defined in several ways and the right choice depends on the situation. This report considers several possibilities for the numerator and the denominator. Another important consideration is the unit of observation. Labor productivity can be used at all levels of aggregation, even down to the individual worker. The output definition has to be chosen appropriately for the unit of observation as more of the environment will be exogenous if the unit of analysis is smaller, e.g. the output mix, output prices, technology used, etc. will not be choice variables anymore. This is also explored in greater detail.

For comparisons across production units that vary in important ways, the concept of total factor productivity (TFP) is often preferred. TFP is defined as the output difference that cannot be explained with (weighted) input differences. It normalizes output not only by the difference in labor input, but also takes other inputs, such as capital or material inputs, into account. The benefit is greater comparability for units that operate with a different input mix, for example because they face different factor prices. The disadvantage is that TFP is only defined relative to a particular production function, as it incorporates an explicit assumption on input substitution (Van Biesebroeck, 2007b). Labor productivity, on the other hand, also has an absolute interpretation. We return to this distinction when we review the sources of labor productivity differences.

Part B of this paper surveys the theoretical and empirical evidence on the relationship between wages and productivity. The competitive model of a spot labor market predicts that all workers will be remunerated at the marginal productivity of the market-clearing worker. We discuss how worker heterogeneity has been incorporated in this model and how asymmetric information, idiosyncratic matching, and institutions can lead to deviations from the simple benchmark. The empirical evidence on the observed relationship is reviewed afterwards, followed by a discussion of several issues of particular policy interest and three case studies.

PART A: MEASUREMENT ISSUES

2. Numerator: value added or output

2.1 Physical output

The most straightforward way to quantify output is as physical output or production volume, as in the number of specific widgets produced. The relationship with the production process that uses the labor input is most transparent and the resulting labor productivity measure is very intuitive. However, its use in economic studies is only appropriate when two conditions are met.

First, the units of observation must be highly comparable, both in terms of the technology used and the type of good produced. An example is Van Biesebroeck (2003) who uses the number of vehicles produced as the output measure for productivity at automobile assembly plants. This works well for a particular production stage in the industry, but would not be appropriate at the firm level as different firms differ in their degree of vertical integration. The similarity of the different assembly plants in a single country (the United States) for a limited time period leads to only small variations in capital-labor ratio, which shows up as small and insignificant output elasticities for capital in a production function. Even in such a situation, it is a good idea to control for product differences in any subsequent analysis of the productivity numbers. For example, Van Biesebroeck (2007a) uses hours of labor input per vehicle as labor productivity measure, but includes dummy variables for vehicle segments (compact cars, intermediate cars, pick-up trucks,…) as controls when explaining the productivity differences.

Second, physical output is only appropriate for a micro-level analysis, at the level of individual workers or at most for plants as units of observation. Moreover, output must be clearly attributable to the unit of observation for the productivity measure to be informative. The presence of multiple outputs also makes the use of physical output problematic as aggregation across products will be ad-hoc, except when revenue shares are used (see next section). Lazear (2000) is a nice illustration of a situation ideally suited to the use of physical output. He uses the number of automobile glasses installed by workers at one particular company to study the impact of compensation—piece rates versus hourly wage—on productivity. In this case, all workers use the same technology, they are individually responsible for their output, and they have no responsibility over pricing.

Physical output facilitates comparisons across countries and across time as currency differences and price changes do not influence measured output. The work at the OECD on Regulatory Reform has constructed national labor productivity statistics for several narrowly defined service sectors (often dominated by a single incumbent producer) using physical output measures: the number of landlines (in telecommunications), kWh of electric power generation (in electricity supply), or total passenger-kilometers (in air transport). Several of these studies appeared in a special issue in June 2001 of the OECD journal Economic Studies; see Gönenç, Maher, and Nicoletti (2001) for an overview.

Some recent studies peel away output price variation from productivity (Foster Haltiwanger, and Syverson, 2008) or even input price variation as well (Atalay, 2012). The idea is that firms face a fixed and exogenously given demand curve for their output or a supply curve for their inputs and they can select a profit maximizing point on those curves. Output price variation across firms is considered to be the result of existing differences in demand and when the objective is to compare (physical) output we should filter out those sources of variation. In this view, the extent to which firms can exercise market power and sell their output at higher prices should not be considered a productivity advantage. The same holds on the input side, where a firm's advantage in commanding lower input prices should be stripped out of a TFP estimate.

These adjustments will bring the results for productivity measures that use a value concept of output closer to those using a physical output concept. Whether this improves the accuracy of the estimates depends on what one wants to include in the productivity measurement. If one is convinced that performance is solely the result of efficiency differences in production, it is the right approach. One has to realize that approaches that use physical output or that adjust the value of output for firm-specific price differentials ignore the value added that is created in the sales or in the purchasing department.

2.2 Gross output

The most straightforward alternative to physical output is total sales or revenue. To make the measure comparable over time it is usually deflated with an industry price deflator and called gross output. For production units with a single output, it is simply the physical output multiplied by the final good selling price. If there are multiple outputs, gross output is the sum of the price times quantity over all goods produced. For aggregate units of observation, e.g. sectors, the summation is additionally over all active plants or firms.

Gross output is frequently used to construct a "total factor" measure of productivity, where it is adjusted for all inputs used. The EU KLEMS Growth and Productivity Accounts (http://www.euklems.net) make such an analysis possible at the sectoral level for a variety of countries (O'Mahony and Timmer, 2009). In addition to labor (L), output can be adjusted for the use of capital (K), energy (E), and material inputs (M). When material input is explicitly included in a production function, the analysis allows for different output elasticities with respect to intermediates by sector.

When gross output is used in the numerator of labor productivity and only normalized by labor input, it leads to a measure that is often not comparable across different observations. Small differences in the intensity of intermediate input use, for example because of differences in the extent of vertical integration or in the use of higher quality intermediates, easily lead to widely varying results. The reason is that in manufacturing on average two thirds to three quarters of the value of output is accounted for by intermediate input use. Neglecting an adjustment for capital intensity, which is always the case for labor productivity, is much less problematic as the importance of capital services in total output is an order of magnitude smaller than intermediates.

Gross output is generally only used in the numerator of labor productivity when the necessary information to calculate value added is not available (see next section). This is often the case in analyses of the service sectors, but fortunately this sector of the economy also tends to use intermediate inputs less intensively. One example is Foster, Haltiwanger, and Krizan (2006) who use total deflated sales by store as the numerator in labor productivity of retail establishments.

2.3 Value added

For an analysis at a more broad level, for example the sectoral level, or when comparing firms that operate in different sectors, it is unavoidable to convert physical output into a value concept to make it comparable. Multiplying with a market price is the only way to make measures like "vehicles per worker" and "landlines per worker" comparable. For units with multiple outputs, multi-product firms or sectors, Caves, Christensen, and Diewert (1982) illustrate that revenue shares are the optimal weights to aggregate outputs.

When comparing production units that operate with varying degrees of vertical integration, it is equally important to adjust for the intensity of intermediate input use. While some firms purchase only raw materials and add most of the value themselves, other firms purchase processed and more costly intermediates which allows them to produce more output with fewer workers. Such an adjustment is also necessary to compare between firms at different stages in the vertical production chain. Firms operating further downstream will tend to pass on a lot of value that is generated upstream when they sell their output. As their workers are only responsible for the slice of value that was added in their particular step in the production process, an adjustment is needed.

The most straightforward approach is to simply subtract purchased materials and intermediate inputs from gross output to obtain value added as output measure. When necessary, further adjustments are made for indirect taxes or subsidies. When information on sales is collected at the retail level, distribution margins need to be subtracted as well.

An alternative way to construct value added is to calculate it from the ground up by adding up its components. Its three components are total labor expenditures, capital depreciation, and operating profit. The first element is the sum of the wage bill and the cost of all other employment benefits. The second element represents the cost of the capital that is consumed as capital services in the production process. In principle, this is a straightforward element in total cost, but in practice it is hard to disentangle from changes in the valuation of the capital stock and from expenditures related to the way the capital stock is financed. The company accounts will record interest payments associated with debt financing, dividend payments associated with equity financing, and net appreciations or depreciations of the capital stock. All of these are only indirectly related to the gross consumption of capital. Operating profit, the third element, is also tricky to calculate as the accounting entries are influenced more by tax policy than by economic profits. Moreover, accounting profit will include a risk premium to compensate capital providers, but some of this will already be counted in the disbursed dividend stream.

Griliches and Ringstad (1971) provide an early justification for the use of value added rather than gross output in the estimation of a production function, which also applies to the calculation of labor productivity. It is valid if intermediate inputs are used in fixed absolute amounts or, the more practically relevant situation, if intermediates are used in fixed proportion to total output. Crucial is that there is no substitution between intermediates and other inputs, such as labor or capital, for the units of observation considered. Even when this last assumption is violated, value added is still valid when used for productivity comparisons over time and the share of material input in total output is stable. Only when the output elasticity of materials is (much) lower than unity and different observations in the sample operate at (very) different levels of vertical integration will the use of value added be misleading.

2.4 Adjust for prices: across units or over time

To make value added or gross output comparable over time, the nominal values need to be deflated to control for the average evolution of the price level. The objective is to measure how real output evolves.

For gross output, the producer price index is usually used, ideally defined for an industry classification that is as narrow as possible. For value added, it is preferable to separately deflate the output and the material inputs before subtracting the latter from the former. When the price index for output and inputs evolve differently, it is misleading to subtract the nominal values in each year and only deflate the difference as it will make the evolution of value added a function of the difference in the growth rate of the two price indices. Sato (1976) contains a detailed treatment of the properties of a double deflated value index and compares alternative index numbers.

Given the objective to measure the evolution of real output, it is important in some sectors to control for quality change. This is achieved by imputing an appropriate reduction in the price index to reflect that because of quality improvement each unit of output has become more valuable to consumers. National statistical agencies quantify the value of quality changes using two statistical techniques. Hedonic price regressions decompose the price of all goods into the valuation that consumers implicitly attach to the observable characteristics. The estimates can then be used to predict the added value generated from a set of improved characteristics. Matched model indices are an alternative approach. They exploit the observed price decline or the loss in market share experienced by unchanged goods that are sold in consecutive years when they face new and improved products in the market place. Pakes (2003) compares both approaches. Results in Van Biesebroeck (2009) suggest that U.S. price deflators incorporate such adjustments to a greater extent than in other OECD countries.

While price deflators control for the general evolution in the price level, an individual firm's price can also rise because it exploits market power. Comparisons over time are likely to be rather insensitive to this, but comparisons across firms are strongly influenced by firm-specific price differentials. A recent paper by Foster, Haltiwanger, and Syverson (2012) suggests that more of the measured productivity differences between plants are the result of demand differences than production efficiency differences, especially comparing new entrants to older incumbents. They reach this conclusion using estimates for only a few homogenous product sectors, but it could be a general phenomenon. In general, there is no good solution as it is not straightforward to define a unit of output in many differentiated goods sectors and detailed price information is not available either. At a minimum it is good to keep in mind that measured productivity will incorporate anything a firm has done to boost the demand for its products.

Finally, when comparing productivity in different countries, output valued in different currencies needs to be converted to a common unit. For country-level comparisons, purchasing power parities (PPP) as constructed by the International Comparison Program of the World Bank and the OECD are commonly used. Van Biesebroeck (2009) illustrates that relative prices tend to evolve differently by country which makes it necessary to construct a disaggregated conversion factor to compare the productivity evolution at the sectoral level across countries. The industry-specific PPPs included in the EU-KLEMS data set have some issues, but they are the best available alternative to aggregate PPP (O'Mahony and Timmer, 2009).

3. Denominator: labor input

3.1 Quantity of work

The denominator of labor productivity measures the total amount of labor input that went into the production of the value created in the numerator. The most straightforward concept to use is the number of workers. At the national level, aggregate labor productivity only differs from GDP per capita by the extent that the active workforce only represents a fraction of the total population.

The number of workers is a stock concept, a one time snapshot, while output is inherently a flow over a time period. Hence, the total number of hours worked by all employees is a more appropriate labor input concept. Only when the average number of hours worked per employee fluctuates or differs between firms that are being compared will the two concepts produce different results. In the Longitudinal Research Database, the firm-level data set for the U.S. manufacturing sector maintained by the U.S. Bureau of the Census, hours worked is only available for production (blue-collar) workers. For productivity analysis, most researchers impute the hours for non-production (white collar) workers which are on monthly wage contracts using a fixed annual average.

The same stock-flow mismatch also plagues the calculation of productivity for firms that newly enter the industry. Output produced will be roughly proportional to the fraction of the year the firm has been in operation. In contrast, the number of employees is independent of the starting date and might be similar in subsequent years even if the firm only operated for a fraction of the initial year. Without adjustment productivity will be underestimated in the entry year and productivity growth will be overestimated. The problem might not be detected as one might plausibly interpret the strong growth as a result of learning-by-doing.

Similarly, when information on both production (output) and sales is available, it is better to use the first variable as the latter might include sales from inventory, i.e. from past production. With information on sales and end-of-year inventory of finished goods it is possible to adjust output for inventory changes to approximate production for the year. If a firms makes a significant fraction of its revenue from the re-selling of own purchases and employees in its sales and purchasing division are not reported separately, it might be best to include total sales and total employment, as long as it is possible to subtract intermediate inputs and measure value added. The general idea is straightforward: as much as possible, make sure the labor input concept used in the denominator is representative for the period over which the output in the numerator was produced.

In the absence of information on the number of hours worked, it is sometimes possible to adjust for the fraction of part-time workers; see for example Van Biesebroeck (2005). Each full-time and part-time worker is assigned a fixed number of hours—based on a national or sectoral average—before aggregating to a number of full-time equivalent workers. If available, the fraction of the wage bill for different worker categories could also be used to construct a weighted average, but care is need as there is often a wage discount for part-time workers. In addition, part-time workers are disproportionately women and they also tend to be paid less per hour.

Adjustments for hours worked are more important in some sectors than others. Retailing or hotels & restaurants are sectors that typically employ many part-time workers. On the other hand, manufacturing industries of durable goods are notoriously cyclical with reduced work hours in cyclical downturns. Bresnahan and Ramey (1994) illustrate the different margins of adjustment for labor input in the automobile industry, but such detailed information is almost never available. An adjustment using sectoral capacity utilization can be used to verify the sensitivity of results to the business cycle. Finally, sectors like agriculture and tourism are very seasonal and tend to employ many temporary workers. Given that most firm-level data sets measure the number of employees at one particular point in time, using the same reference date for all firms, care is needed to make sure the labor input stock is representative.

3.2 Quality weighting

The contribution of labor services to the production process has not only a quantity, but also a quality dimension. To increase output, a firm can use more workers or employ more productive workers. To express labor productivity in efficiency units, the output value created by a benchmark worker, differences in the composition of the workforce need to be controlled for. When we measure productivity growth, we want to know how much the output of a typical or average worker has increased. If a firm has adjusted the type of workers it employs, for example by employing a more educated workforce, we may want to filter out the contribution of the human capital and only identify the output increase that a comparable workforce would have generated. Similarly, when comparing two firms, we may want to adjust their workforce to make them comparable and identify output differences that are tied to the firm. In the growth accounting framework that underlies the calculation of TFP, the human capital embedded in workers is treated as a source of capital and subtracted from output using appropriate weights.

Griliches and Jorgenson (1967) decomposed total labor input growth additively into the growth rate for the number of workers, growth in hours worked per employee, and a growth rate of human capital. The latter is a weighted average (using relative wages) of the growth rate of employment shares in each worker category. If employment increases more rapidly than average in a worker category that has above average wages, this increase will be counted as an increase in the use of human capital and be deducted from output in the calculation of TFP. When input use is so accounted for, both in terms of utilization rates and quality improvements, they show that it explains the majority of output growth, leaving only a relatively small fraction of output growth (approximately one fifth) as a TFP residual.

When calculating labor productivity it is also possible to account for cross-sectional differences or time-series changes in the type of workers. A productivity-adjusted labor aggregate can be calculated as the weighted sum of the number of employees over all worker categories. The relative wage for each category relative to the benchmark, lowest wage, worker category serves as weight:

$$\begin{aligned}\tilde{L} &= \sum_k \frac{w_k}{w_0} L_k \\ &= L \times \left[\sum_k \left(1 + \frac{\Delta w_k}{w_0} \right) s_k \right]\end{aligned}$$

The aggregate is expressed in efficiency units, using the productivity level of the lowest paid worker category as benchmark. The second line illustrates that it amounts to an adjustment of the total unadjusted labor force (L) by a factor that multiplies the worker share in each category by one plus the percentage wage difference of each worker category.

4. Unit of analysis

4.1 Individual

The simplicity of the labor productivity concept, both in terms of the calculation and the interpretation, implies that it can be used at all levels of aggregation. As long as it is possible to identify an output flow that is plausibly under control or the result of actions taken by the workers included in the denominator, the ratio will be informative. It means that in some situations it can even be calculated at the individual level.

A straightforward application is to single-person firms. In some countries, the limited accounts that small firms need to file with the business registry or a government agency contain sufficient information to calculate value added and employment. Under the value added tax system operated in most European countries, for example, administrative data exists on annual sales and total input purchases for all firms that meet a (sometimes low) sales threshold. Single household farms are common in agriculture and using survey evidence it is sometimes feasible to estimate labor productivity at the individual-level if individuals are assigned personal responsibility for a plot of land. Some applications exist studying productivity of self-employed individuals; see for example Moore (1983) and Lazear and Moore (1984).

In some situations, the work of employees of larger firms is sufficiently self-contained that one can identify the output that a single individual is responsible for. The example of workers installing automobile glass in the Safelite Glass Corporation in Lazear (2000) has already been mentioned. A similar example is Seiler (1984) who studies the individual output of 100,000 workers that are employed in 500 different firms in the footwear and clothing industries. He also studies the productivity impact of piece rates or time rates.

These applications are not limited to manual laborers. The vast literature that investigates whether CEO compensation is excessive or not has developed more involved output measures to evaluate the performance of company executives. Kaplan (2012) provides an overview of the recent literature and calculates (marginal) productivity statistics for CEOs, using their impact on a firm's market capitalization as output measure. Event studies have similarly exploited movements in the stock price of a company to evaluate successor announcements. The productivity of individual researchers is also studied in detail in the vast literature on the sources of innovation. For example, Dietz and Bozeman (2005) study the performance of scientists working in academia as well as the private sector, using both published papers and patents granted as output measures.

4.2 Plant or firm

The most extensive and intuitive use for labor productivity is to compare the performance between plants or firms or the evolution of their performance over time. One benefit of labor productivity over TFP when comparing between firms is that comparisons are automatically multilateral because the absolute level of labor productivity has a direct interpretation. In contrast, for TFP one has to assume a particular functional form and impose the same production technology on all firms, or one has to compare each unit to a hypothetical average firm, or one is limited to only bilateral comparisons (Van Biesebroeck, 2007).

The most important measurement problems have already been mentioned above. One difficulty that is particularly relevant at the firm or plant level of aggregation is worth discussing. Even if we know employment, output, and material inputs for a particular production site, if the establishment belongs to a multi-unit firm it will generally consume some headquarter services that are not performed locally. These might include support services such as human resources and finance, but also the work of sales, purchasing, and marketing departments. In contrast, single-plant firms will perform all activities locally on site. As the internal organization of firms is bound to vary and headquarter services are generally not observed, the number of employees might not be comparable across observations.

One research area where this is particularly troublesome is when comparing the productivity level between domestic and foreign-owned firms. At one extreme are small single-plant firms that perform all activities in a single location; at the other extreme are large domestic firms that have national headquarters in the vicinity where most office work is performed. Foreign-owned subsidiaries tend to be intermediary, with some services performed at headquarters, but not the entire range because regulations differ across countries and headquarters are likely to be located further away.

In the application to automotive assembly plants in Van Biesebroeck (2007), the full range of activities performed at each production location is observed. To make the labor productivity calculation, hours-per-vehicle, more comparable, a set of core activities which are performed everywhere is selected and only workers performing those activities are counted. But, in general, such detailed information is not available.

A new survey piloted by the U.S. Bureau of Labor Statistics holds some potential. Establishments—production plants or any other location where economic activities take place—receive a form that lists around 40 economic activities—business functions. These include production, purchasing, sales, R&D, human resources, etc. Firms are asked to indicate which activity is performed on site and how many workers are employed in each division. A similar project exists at Eurostat to collect information on employment by business function at the establishment level. The European project focuses specifically on international sourcing (Alajääskö, 2009).

When there is some element of team production, which is the case in most occupations, it is impossible to calculate productivity at the individual level. If output is inherently the outcome of a team effort, productivity is also only defined at the level of the entire team. By supplementing plant-level statistics on output and input use with detailed information on characteristics of the workforce, it is nevertheless possible to identify productivity premiums associated with worker characteristics, such as education or gender. These premiums are defined relative to the productivity level of a benchmark worker category, they have no absolute interpretation. Fox and Smeets (2011) perform such an analysis and they find that these characteristics explain only a small fraction of the variation in firm-level productivity.

4.3 Sector

Naturally, labor productivity can also be calculated at the sectoral level. An interesting property is that when firm-level statistics are aggregated using labor weights, i.e. the employment share of each firm in the sector, the average of the micro-level estimates exactly replicates the ratio of aggregate output to aggregate input. This is not the case for TFP.

An important drawback is that capital-labor ratios tend to differ a lot across sectors. For example, the mining industry in virtually every country has an average level of labor productivity that is far higher than the economy average. Similarly, within the manufacturing industry the chemical sector also tends to have a higher than average level labor productivity. Such differences seem to suggest that large output gains could be had by reallocating workers between sectors. Such a comparison is misleading, though, as workers in those sectors need a lot of complementary inputs, notably capital. The labor productivity we calculate is not the contribution of the marginal worker, keeping everything else fixed, but the average contribution.

Given that technologies and capital-labor ratios are relatively stable over time, labor productivity growth rates are more comparable across sectors. However, in some situations even here caution is warranted. Brandt et al. (2012) study the manufacturing sector in China between 1998 and 2007. The extremely low interest rates that the government imposed in order to channel investment into the manufacturing sector lead to rapidly growing capital-labor ratios. As a result, labor productivity growth rates were substantially higher than TFP growth, but this was true to a different extent by sector. Not each sector was able to increase the capital-labor ratio as easily and not each sector received the same easy credit.

Technologies are also relatively comparable across countries, this is even an explicit assumption of the standard Heckscher-Ohlin theory of international trade. As a result, comparisons of the labor productivity level of individual sectors across countries are also feasible. Especially if the countries are of similar level of development and the factor price ratio, the wage rate relative to the cost of capital, is likely to be similar. Converting the output to a common currency, while accounting for international differences in relative prices is the greater challenge here, as discussed earlier.

4.4 Country

At the national level, GDP (or GVA) per capita is the most widely used measure to compare countries. The currency conversion is usually done with PPP, as mentioned earlier, to account for cross-country differences in price levels. The measure has an income interpretation—how rich is a country?—but GDP is equally well calculated from the production side. It measures the total value added of all economic activities performed in the country. GDP per capita can be divided by the activity ratio of a country—the fraction of the population that is in the workforce—to obtain output per worker. However, cross-country differences in output tend to be so large that they swamp this adjustment.

Moreover, the activity ratio is endogenous and it reflects a country's ability to recruit people into the workforce. It depends on the application whether one wants to exclude this effect from the performance comparison or not.

5. Issues of particular relevance to LDCs

5.1 Informal sector

Many of the insights in terms of firm dynamics in the manufacturing sector of developing countries have been surveyed in Tybout (2000) and Bigsten and Söderbom (2006). A few of the unique features of firms in developing countries they highlight have implications for the measurement of labor productivity.

A first feature that is impossible to ignore is the importance of the informal sector. Especially in sectors outside manufacturing, informal firms are responsible for an important share of economic activity. Van Biesebroeck (2005) demonstrates that there is a very steep productivity premium related to size in the manufacturing sectors of seven sub-Saharan countries. The formal sector systematically attracts more productive firms which will bias measured productivity differences obtained from any administrative data set upwards. Brandt et al. (2012) illustrate that in 2004 in China 91% of manufacturing output is produced by above-scale firms (with annual sales above 5 mio. RMB) even though smaller firms are responsible for 29% of employment in the manufacturing sector.

One way around this problem is to compile a sample as in the studies included in Liedholm and Mead (1999). Rather than relying on self-registration by firms into an official business registry, a large number of interviewers exhaustively surveyed all houses in a well-defined geographical area to find out whether any 'businesses' (broadly defined) were operating in that location. The resulting sample shows that there are a very large number of very small firms, often with only one or two employees.

Hsieh and Klenow (2012) used this sampling method more recently for India. They not only find a large number of micro-firms, but find moreover that these firms often stay small. It is not uncommon for firms to have only a few employees, basically still be a household firm, even after being in operation for thirty years. This is in sharp contrast with evidence for the United States where young firms either grow rapidly or exit relatively quickly with the distribution of entry cohorts rapidly converging to the industry average. Given that a lot of the productivity growth comes with scale, often through the greater capital-intensity of operations and the technical progress embodied in equipment, the prevalence of small informal firms is hampering (productivity) growth in developing countries.

A different manifestation of the importance of the informal sector can be seen in delays in updating the national firm registry. This is especially true in fast growing economies as most statistical agencies use a minimum size threshold before firms are surveyed. When the size threshold is related to employment and the firm collects income tax, it is not too difficult for the statistical agencies to know when to start surveying a firm. However, in some countries the size threshold is related to revenue. Brandt et al. (2012) show that in China, the sample of above-scale firms, those with sales above 5 mio. RMB, jumped by more than 30% following the 2004 manufacturing census. Many firms had already reached this threshold in earlier years, but it was only when every single manufacturing firm was surveyed as part of the full census that this was discovered. Given that this delay omits fast-growing successful firms from the sample, it will tend to bias average productivity growth downward.

5.2 Undercounting of inputs

Just as firms are missed, administrative records in development countries are likely to undercount labor input if firms rely on family workers and casual employment, even day laborers. If the firm's output measurement is not affected, it will lead to upwardly biased labor productivity estimates. Surveys can account for this by explicitly asking for employment in different categories. For example, the RPED surveys underlying the review of Bigsten and Söderbom (2006) explicitly questioned firms on the employment of family members and asked to report casual, seasonal, or part-time workers.

Even when workers are counted, the actual labor input is likely to be more variable than in developed countries. Unmeasured overtime work is widespread in larger firms, while underemployment of the existing staff is widespread in smaller firms. Unmeasured weather inputs, which tend to be important in agriculture, are also likely to introduce measurement error.

Other inputs—raw materials, energy, intermediates—are sometimes measured for institutional reasons. Examples are sales tax evasion or because they entered the country through parallel import channels to avoid high import tariffs. Given that these inputs are subtracted from sales to construct value added, omitting some of them will lead to an overestimate of labor productivity. The effects could go both ways depending on the exact institutions. In China, for example, the cost of imported inputs subject to import tariffs might be understated as duty-free inputs originally destined for the export processing sector leak into the wider economy. In contrast, the value added tax that firms have to pay on final output will be partially rebated if the output is exported, and this rebate is not always counted in output.

5.3 Other measurement problems

As measured earlier, prices need to be deflated to make productivity comparisons over time. The more detailed the definition of sectors, the smaller is the scope of firm-specific price differences to distort real output measurement. In several studies, especially for smaller developing countries, the only price deflator available is an economy-wide purchasing price index or even only the national consumer price index.

A related problem is the presence of localized markets due to geographic barriers. It leads to monopoly power with higher prices on the output side and monopsony power with lower wages on the input side. As a result, real output is overstated and the quality of labor understated if the productivity measure adjusts for human capital. More generally, market frictions tend to be higher in developing countries; see Hsieh and Klenow (2009) for evidence for India and China and Van Biesebroeck (2011) for evidence from sub-Saharan Africa.

PART B: WAGES AND PRODUCTIVITY: A SURVEY OF THE LITERATURE

6. Theoretical issues

6.1 Competitive wage determination

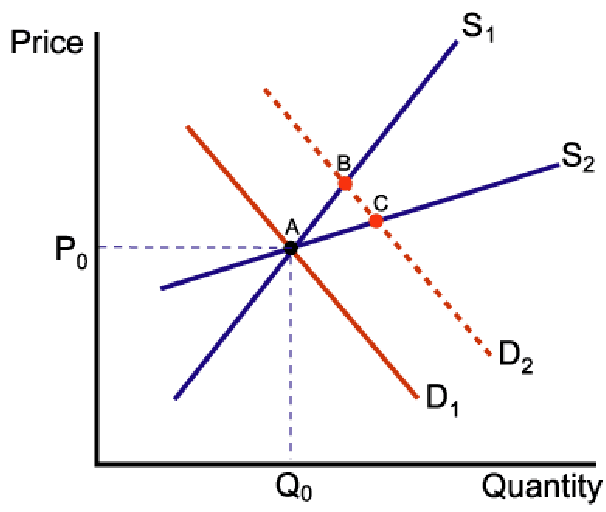
How tight is the link between wages and productivity? The textbook derivation of the labor demand schedule leads to a first order condition for the firm that equates the wage to the marginal product of labor. A firm will add employees to its workforce until the additional value produced by the last worker hired equals the going wage rate. If there are other inputs used in production, such as quasi-fixed physical or managerial capital, this marginal product schedule will be downward-sloping. The available capital needs to be shared over more workers when employment rises.

If a firm is a price taker on both the output and the labor market, the price of its final output will not vary with its own production. The marginal product is then simply the derivate of the production function with respect to labor, an almost purely technological relationship. In the absence of technical and allocative inefficiencies there is hardly any decision making involved: keep hiring workers until their marginal product falls below the exogenously given wage rate. If a firm has market power in the final goods market and faces a downward-sloping residual demand curve, it will have a steeper labor demand curve. An increase in employment will not only reduce the marginal product on the factory floor, but selling the additional units of output requires a lower output prices. It makes the marginal value product of labor decline more rapidly.

From a macroeconomic perspective, the labor market is assumed to clear where the downward-sloping labor demand curve from the business sector intersects the aggregate labor supply curve from the household sector. If the marginal disutility of work is positive, the labor supply curve will be upward-sloping. Most individual workers are estimated to have a very low elasticity in their labor supply once they are employed. Nevertheless, as wages rise more workers enter the labor market, which makes the aggregate labor supply upward-sloping.

Many models assume for simplicity that individuals do not value leisure and the labor supply is perfectly inelastic (vertical). In such a situation, shocks in worker productivity will show up one-for-one in wages. In neo-Keynesian models with staggered wage contracts or with sticky prices, the adjustment to a productivity shock will at least partially be in quantity, i.e. in the level of employment, rather than in wages alone. As usual in economics, the extent to which a shock is felt in price or quantity, or in this case in the wage or employment, is governed by the relative elasticities of the aggregate labor demand and supply curves. Even if a positive productivity shock does not filter through entirely into higher wages, it will still be the case, in this framework, that the labor productivity of the marginal worker equals the market-clearing wage on the (spot) labor market.

Figure 1: Effect of productivity shock on wages (P) and employment (Q)



If we believe that the long-run labor supply curve is almost perfectly inelastic, the standard assumption in macroeconomics, productivity advances will eventually find their way into wage increases. In Figure 1, the effect of a productivity increase that shifts the labor demand from D1 to D2 has a larger impact on wages, and smaller on employment, the steeper the labor supply curve is. S1 could be considered the relevant supply curve if the adjustment period is longer. In the short run, workers might be convinced to work more when faced with a higher wage, as indicated by S2, but as workers adjust to their higher welfare they will resort back to their usual work-leisure trade-off.

For workers to the left of the hypothetical full-employment situation Q0, it will necessarily be the case that wages are below the "marginal" labor productivity which defines the labor demand curve if it is downward-sloping. The word "marginal" is in brackets, because these workers are not really infra-marginal. As long as workers are homogenous, only the last worker in the line from 0 to Q0 is marginal, and she is paid her marginal product. The productivity of the second last person on that line is indeed higher than the market-clearing wage, but in that counterfactual situation without the last person present—which would make the second last worker the marginal worker—the market-clearing wage would also be higher.

The same holds on the labor supply side. Workers to the left of Q0 receive a wage that is higher than their marginal cost of providing the labor, i.e. the disutility of work that is captured by the supply curve. These workers seem to receive some rents, a higher wage than necessary to convince them to work, but they are not marginal. If another worker existed with an equally low disutility of work, the supply curve would be lower at Q0 and also the market-clearing wage.

6.2 Extensions

6.2.1 Worker heterogeneity

An important feature of the labor market is that workers are clearly not homogenous and they do not all earn the same marginal wage. The most straightforward way to incorporate this into the above model has been to define separate labor markets by worker type. The above analysis is then performed for each class of workers separately, e.g. men and women, workers with a high school diploma and college educated workers, etc.

A more practical approach is the Mincer (1974) model of human capital which can incorporate several worker characteristics at the same time. The total remuneration of a worker is viewed as a base wage, the marginal productivity of a benchmark worker, plus a wage premium associated with each worker characteristic that raises human capital. Firm arbitrage will now equate the wage premiums associated with each characteristic to the productivity premiums these same characteristics bring in the production process. This equality follows directly from the firms' first order conditions, characteristic by characteristic, if different workers are perfect substitutes (we illustrate this in a later Section). The better substitutes heterogeneous workers are, the more competition across worker types can substitute for competition within worker types.

In the Mincer model, the total wage (Wi) can be written as

$$W_i = W_0 \cdot \exp(\lambda_M M_i + \lambda_S S_i + \lambda_X X_i + \cdots),$$

the product of the benchmark wage (W0) and wage premiums associated with different characteristics, e.g. gender (Mi equals one for male workers), years of education (Si), years of labor market experience (Xi), etc. The λ parameters capture the percentage difference from the benchmark worker, a female worker without zero years of formal education and labor market experience. After taking logarithms it produces the widely estimated Mincer wage regression:

$$\ln W_i = \lambda_0 + \lambda_M M_i + \lambda_S S_i + \lambda_X X_i + \cdots$$

A common assumption is that the percentage wage premium associated with each year of labor market experience is not constant, but rather the elasticity (is constant). This can be incorporated straightforwardly by replacing the λX Xi term with λX ln(Xi).

Education is one of the most salient features that differentiates workers. Given that it is an endogenous characteristic that needs to be invested in and that policy can conceivably influence, it has received a lot of attention. Heckman, Lochner, and Todd (2006) review the evidence from the Mincer model of human capital and point out several problems. In particular, the uncertainty associated with the stream of future benefits associated with education, due to the difficulty predicting the future wage premium and uncertainty about graduation, noticeably lowers the present value of education to individuals. Even if workers are making rational investment decisions, the marginal return should be derived from an explicit model of decision-making under uncertainty.

Some empirical studies have exploited changes in compulsory schooling laws which allows them to identify the returns to education by abstracting from endogenous worker decisions. They suggest extremely large returns to schooling and suggest that most high school dropouts could raise their lifetime welfare by staying in school; see for example Oreopoulos (2007). Given that individuals have to decide their schooling levels in a forward-looking manner at a young age, the evidence on high discount factors for teenagers and inherent uncertainty in the return to schooling will naturally be important factors. Even if the model is accurate in the sense that schooling is correctly rewarded at the margin for the individual, i.e. in line with the productivity gains it brings, there might be underinvestment from a social perspective. Some authors have used this to argue for direct government intervention or subsidies for education.

Of course, human capital formation goes beyond formal education prior to entry on the job market. For example, Mincer (1962) finds that on-the-job training makes up at least half of an average worker's human capital. This begs the question to what extent human capital is portable. The model that predicts equality of wage and productivity premiums associated with worker characteristics relies on firms competing for workers to bring the equality about. If much of a worker's human capital is firm-specific and not portable to other employers, arbitrage will not be enough for the workers to capture the productivity benefits of their own human capital.

Topel (1991) finds very high wage effects of employees' tenure with a particular employer and interprets them as firm-specific human capital. Altonji and Williams (2005) contest these findings and Brown (1989) illustrates that the link between tenure and wages is closely tied to on-the-job training. Finally, Dustmann and Meghir (2005) use a novel identification strategy—exploiting closures of German plants—to distinguish the returns to experience and tenure in a firm or sector. For skilled workers, they find positive returns to experience and firm tenure; for unskilled workers the effect of experience becomes insignificant beyond two years, while firm tenure has a consistently positive effect on wages.

Workers are heterogeneous, but so are firms. More productive workers could perhaps have earned the same wage everywhere, but it is also possible that they are matched with more productive firms that pay all their workers above average. Abowd, Kramarz, and Margolis (1999) investigate the source of above average wages using a longitudinal sample of matched employer-employee data for France. They find that individual worker effects explain almost 90% of inter-industry wage differentials and about 75% of the firm-size wage effect. In contrast, firm effects explain relatively little of either differential. Some studies, however, do find that higher profits at the industry level are systematically related to higher pay for workers. Obviously this raises important endogeneity questions and we discuss this topic in Section 5.3 where we relax the assumption of competitive factor or product markets.

6.2.2 Location of work

The theory of international trade and FDI takes a very different approach to the same wage-productivity relationship. It studies the location of production, as a choice variable of the firm, taking wages as given. From the firm's perspective, wages are now exogenous, but their location decisions will, in equilibrium, determine both a country's wage level and its aggregate productivity. Helpman (2006) provides an in-depth overview of this literature.

In many models technology differs between countries. It leads to higher productivity in some countries and lower productivity in the rest of the world. If there are scale economies, an exogenous size difference between countries can generate such a productivity difference endogenously. Often the difference is simply the result of the past history. Given these primitives, firms will choose a location and hire workers, always paying wages equal to the marginal productivity which in these models tends to be constant.

Of course, mobility is not limited to firms. Workers can also migrate between countries and to the extent that they do, it resurrects the national model of labor markets discussed earlier. Workers will migrate if their expected earnings abroad—a function of their productivity—exceeds their domestic earnings sufficiently to cover the switching or migration costs. Given that these costs tend to be sizeable in practice, a substantial wage difference for identical work can be sustained between countries.

Harris and Todaro (1970) developed an analysis to explain national migration from the countryside to the city. Historically this migration coincides with workers moving from agriculture to formal work in manufacturing or service sectors. They wanted to explain the following phenomenon: even though work in agriculture had positive marginal productivity, many workers that moved to the city ended up unemployed not producing much. As an explanation their model featured labor market frictions in the cities—such as market segmentation into formal and informal work, unionization, and corruption in the awarding of well-paid government jobs—that sustained a rural-urban wage gap. Workers are willing to move to the city if their expected wage there, averaging the probability of unemployment and the probability of finding a desirable high-wage job, exceeded their wage in agriculture.

6.3 Deviations from equality of wages and (marginal) productivity

6.3.1 Asymmetric information

A key theoretical reason for deviating from equality of wages and productivity is the presence of asymmetric information. The Mincer human capital framework is an intuitive approach to incorporate worker heterogeneity, but it relies heavily on perfect observability. A different perspective is provided by the vast theory literature of principal agent models that take asymmetric information as crucial ingredient. Selection models feature unobservable worker types that are related to productivity. Moral hazard models assume that some actions of workers are unobservable and thus not contractible.

When worker productivity is unobservable, other characteristics can be used by employers as proxies for the productivity of worker types. The signaling model of Nobel Prize winner Michael Spence introduced a separating equilibrium to sustain differential wages for different worker types, even if they are unobservable. It provides a stylized illustration of how an equilibrium can generate a relationship between a productive trait that is unobservable and an unproductive worker characteristic such as education that is observable (see Spence, 2002, for a recount of his pioneering contributions).

One key assumption is needed for a reasonably efficient separating equilibrium to exist. Workers that will be more productive in the labor market must also be more productive in the acquisition of education, i.e. they can obtain a degree at lower (study) cost. In that case, higher educated workers will command a wage premium even if there is no direct link between education and productivity in the workplace. The link is indirect, through worker type. In the simplest derivation, there is a discrete gap in the potential labor market productivity of high and low quality employees. High productivity workers will endogenously choose to acquire potentially useless education, merely to distinguish themselves from low productivity types. Firms recognize this and competition for educated (high productivity) workers bids up their wages. Low productivity workers could in principle follow the same education strategy and obtain the same wages, but their much higher cost of obtaining the education to begin with makes this unprofitable for them. They rationally decide not to pursue a degree and are paid less in equilibrium.

Note that even when education is not a productive characteristic in its own right, it still helps to connect wages to productivity. This is a general feature of principal-agent models. Rather than pay all workers the same wage, some mechanism is devised to establish a connection between wages and productivity. With uncertainty, the correlation will not be perfect, but it will not be zero either. The only reason firms are willing to pay higher wages to different workers is because there are underlying productivity differences.

The second type of asymmetric information models that has developed is where worker effort is not (perfectly) observable. As a result, the employer will not be able to write a contract that makes the wage conditional on productivity (or effort). A second best solution will be to make the wage conditional on output, but that entails some inefficiency as well.

In the canonical model there is a risk-averse worker that decides on costly effort that stochastically increases output. The employer is risk neutral, but faces an inference problem. An exogenous shock—the state of nature—influences output in addition to worker effort which makes it impossible to know whether high output is due to chance or to high worker effort. It is possible to make the wage contingent on output, which is observable, but this induces a random element in compensation that is outside the worker's control. It gives the worker better incentives for effort provision than under a constant wage, but to satisfy the worker's participation constraint (pay a minimum reservation rate) the expected wage will need to be higher to compensate the risk-neutral agent for the risk she is forced to take on.

Paying a piece-rate, rather than a time rate is a practical implementation of this principle. Rewarding sales agents with a commission is another example. A simple example of the optimal linear contract—with a fixed payment plus a variable part that is a function of output—is derived in Bolton and Dewatripont (2005). Yet another solution would be to sell the firm to the worker. In that case the worker has the strongest incentives (good for output), but also faces the most income variation due to exogenous factors (bad for welfare). Outsourcing tasks to self-employed individuals is a practical example of this latter approach.

Several alterative mechanisms to elicit effort exist. One that has received a lot of attention in the theory literature is tournaments. This is meant as a characterization of the competition among workers for promotion. All workers expend effort in production and at the end of the period it is announced which worker gets the prize, i.e. is promoted. An important advantage of tournaments, from the perspective of employers, is that they do not require the employer to ascertain the absolute productivity of a worker. It is often easier to rank the relative productivity of workers if there are important shocks that influence output, and that influence all workers similarly.

Given that employer-employee relationships tend to be long-lasting, repeated relationships, the employer has many more tools available to elicit effort. One dynamic tool is to make the age-earnings profile slope upward. It will induce workers to provide effort at the start of their career, as there will be a large reward at the end (Lazear 1979). Especially when monitoring is difficult, this is a good strategy to avoid shirking. If the high wage is solely intended to provide effort incentives and not to reward firm-specific human capital that builds over time, such a compensation policy does weaken the correlation between wages and productivity. Early in a worker's career there will be greater incentives to provide effort (boosting productivity), while wages are higher later in a worker's career when there is little incentive for effort provision.

A similar policy is the practice of paying efficiency wages, i.e. a higher wage than the average going market rate. If monitoring is costly, but not impossible, it is sufficient to monitor performance only stochastically, and dismiss workers that are shirking. If a worker is paid a higher rate than could be obtained in expectation at a new employer, this will provide enough of an incentive to induce effort. The presence of steady-state unemployment will have a similar motivating effect (Shapiro and Stiglitz, 1984).

One instance where a firm will purposely weaken the relationship between observable performance and compensation is analyzed by Holmstrom and Milgrom (1991). They study a situation where work is inherently composed of multiple tasks. For some tasks it is easy to observe output of individual workers, but for other tasks output is not as easy to observe or value, for example because there is an important quality component. It can then be optimal to purposely weaken the link between productivity and remuneration in easy-to-measure tasks to avoid distorting effort away from hard-to-measure, but equally important tasks. It might for example be the case that part of a worker's job involves tasks that are performed individually and others that are performed in a team where it is impossible to gauge each individual's contribution to the team output. If there are strong performance incentives on the individual tasks, the risk is that workers will provide as much effort as possible on the individual tasks and as little effort as possible in the team production part of their job.

6.3.2 Search, matching, and bargaining

Even in the absence of asymmetric information, there are other forms of frictions in the labor market. In reality, firms spend a lot of money on recruiting and workers spend considerable time looking for an attractive job. At any point in time a worker will only be matched to a few potential employers and will have to choose between only a few limited options. This situation makes it unlikely that the wage offered will be exactly equal to the worker's marginal product. Moreover, search is costly and time that can be spent without a job is limited for most workers. Under these circumstances it will not even be optimal for a worker to keep looking for a job that pays the full marginal productivity.

To incorporate this feature of the labor market in the model, a literature has sprung up that starts from a match between each worker and a single firm. The decision that each party can make is to consume this match and start an employment relationship or to keep searching for a better match. An exogenous matching function that is a function of the number of workers looking for a job and the number of job vacancies that firms have posted generates a single wage offer for an unemployed worker. The optimal strategy will be to accept the job if it exceeds a pre-set reservation wage or to keep searching for one more period otherwise.

Even if all workers are identical and productivity is perfectly predictable, it will not be optimal for the firm to pay the worker the full marginal productivity. Nor will it be optimal for a worker to reject all jobs paying less than the full marginal product. There will be a range of situations where the outside option of both parties is strictly lower than the marginal product generated in the match and the optimal outcome will be to start an employment relationship. The firm and worker will then bargain to split the match-specific surplus, i.e. the difference between their respective outside options.

One modeling assumption is that the firm posts a wage. This amounts to a take-it-or-leave-it offer and amounts to assigning all the bargaining power to the firm. If workers are heterogeneous, this will still not be enough for the firm to extract the full surplus from the relationship (Burdett and Mortensen, 1998). An alternative modeling solution is to assume Nash bargaining and specifying exogenous bargaining powers for the firm and the worker (Pissarides, 1985). Such studies assume that bargaining takes place between the firm and a trade union that acts as a bargaining agent for the workers. How the surplus is shared between both parties then depends on the relative bargaining weight of labor.

These models generate a number of predictions that are relevant for the wage-productivity relationship. First, they sever the direct link between productivity and wages. With worker heterogeneity, the correlation will still be positive, but necessarily lower than in a spot labor market.

Second, as vacancies and the number of unemployed vary over the business cycle, the posted wages or the bargaining weights will tend to vary over time as well. It induces variation in the equilibrium wages across periods that is unrelated to productivity. If job search is very costly, for example in the absence of unemployment insurance, these short-run conditions could have long-run effects. Oreopoulos et al. (2012), for example, find a sizeable long-run wage depressing effect of graduating in a recession.

Third, cross-sectional factors that influence bargaining power will show up in wages even if they have no effect on worker productivity. Some of the excess remuneration of individual skills—in excess of their productivity contribution—found by Van Biesebroeck (2011) could be due to such effect. In particular the much higher relative wages of male workers in several sub-Saharan African labor markets could reflect bargaining power rather than productive human capital.

Fourth, factors that influence workers' outside options will similarly have an effect on wages. A prominent example is the presence of family assets that permit a higher reservation wage and in expectation a longer period of job search.

6.3.3 Monopsony

Monopsony power on the side of the employer could be another reason for deviations of the wage from the marginal labor productivity. If the firm can dictate wages, it does not necessarily have to pick a wage (price) on its own demand curve, but can pick a point on the workers' supply schedule that maximizes the firm's profit. This will only be feasible if workers cannot easily substitute away to competing employers, for example in the case of geographically localized labor markets or in highly segmented labor markets by occupation.

Manning (2006) shows that once one accepts that the wage elasticity of the labor supply to an individual employer is finite, the distinction between a monopsonist and the perfectly competitive model of the labor market boils down to a distinction of diseconomies of scale in recruiting. Monopsony then corresponds to the case where the marginal cost of maintaining a given stock of workers is increasing in employment.

Two areas where this issue has been researched extensively are in labor markets for health care workers and in development economics. Several studies have found monopsony power for hospitals in the market for nurses; see for example Staiger, Spetz, and Phibbs (2010). This last study even finds strategic adjustments in wages by competing hospitals. Using very different identification approaches both Reardon (1997) and Van Biesebroeck (2011) find evidence of segmented local labor markets in Africa.

6.3.4 Alternative theories of wage determination

We already mentioned that some researchers have argued that higher profits at the industry level are systematically related to higher pay for workers. Kalecki (1938) is one of the first studies on the impact of market power in the final goods industry on the distribution of rents and wages. In later work, Kalecki looked for empirical validation of his theory and showed that high-profit industries also tended to be high-wage ones. Obviously, this raises important endogeneity questions. Are unobserved worker qualities the source of higher profits or are workers able to appropriate some of the profits that originate from uncompetitive product markets. Or even, is the monopsony power of firms on the labor market the underlying reason for both firm profits and a wedge between worker pay and productivity?

We would like to point out two important contributions in this literature. Krueger and Summers (1988) have presented evidence, exploiting both cross-sectional as well as longitudinal variation that workers in high-wage industries receive non-competitive rents. Even after controlling for workers observable and unobservable characteristics and institutional features that are likely to explain sectoral wage differences, such as fringe benefits, demand shocks, actual or threatened unionization, they find a positive association between wages and industry profits for equally-skilled workers. They thus conclude in favor of a causal explanation that industry rents lead to higher wages.

Gibbons and Katz (1992) revisit the same question both theoretically and empirically. They build a model that features both exogenous differences in industry profits, as well as unmeasured firm ability that can lead to wage differences. In a sample of displaced workers they find in particular that after separations, workers that used to earn high wages, relative to their expected earnings based on their observables, also earn above average earnings in their next job. This suggest an important role of unmeasured worker attributes in explaining wage differences, perhaps even industry profits. Other patterns, however, suggest that this cannot be the entire explanation.

To the extent that these studies suggest that rent sharing is an important contributing factor to explain wage levels, they also suggest that bargaining mechanisms matter. As worker wages are determined in a negotiation between the firm and the worker, either alone or collectively, the actual wage levels that materialize will generally depend on the features of the bargaining mechanism. In turn, the division of rents and the discrepancy between wages and productivity also depend on the specific bargaining mechanism used. Manning (2011) devotes an entire chapter in the most recent Handbook of Labor Economics to this issue.

Finally, Segal (1986) discusses that the above patterns as well as other features of the labor market are often quite consistent with (post-) institutionalist approaches to labor market research. Given, for example, the importance of heterogeneity in firm-level productivity that is crucial to modern theories in many fields of economics, it is quite natural to also reserve a role for firm-specific differences in remuneration policies. A drawback of the institutionalist literature is that the models tend to be somewhat ad hoc and cannot be easily applied in a variety of circumstances. Moreover, much of the original features of this stream of literature, e.g. the focus on job search and mobility and the internal labor market in the firm, have become an important part of mainstream labor economics. It does, however, serve as a good reminder that supply factors and human capital theory are only one side of the market and equality of wages and productivity cannot always be taken for granted. In the aftermath of the Great Recession, it is good to see that labor demand has become once again more prominent in economic research.

7. Empirical findings: How tight is the link between productivity and wages?

7.1 Cross-sectional evidence for the "average" worker

We start the review of empirical evidence by ignoring observable dimensions of worker heterogeneity at first. The first question is whether the average wage falls short of the average (comparing across workers) marginal productivity of labor. This is really a question about how the surplus from employment matches is divided between the employer and employee.

The literature survey of Manning (2011) concludes that imperfect competition is pervasive in the labor market and that there are large rents in employer relationships. Marginal workers often earn more than their disutility of work and firms often pay their workers less than the marginal productivity of the marginal employee. As reasons for sustained rents he points to frictions and idiosyncracies in the valuation of specific matches.

From the perspective of the employer, the magnitude of hiring costs provides one important piece of information. A review of the evidence suggests that rents should equal at least 5% of total labor costs. The search activity of the unemployed provides additional information, this time from the side of the employee. The very low intensity of search reported in time-use studies suggests that the wage is fairly close to the marginal cost of providing the labor, i.e. rents seem to be rather low from the employee's perspective. There are two caveats. First, the low search intensity might be due to its ineffectiveness at the margin, rather than the low net value of employment. Second, happiness studies do suggest jobs are extremely valuable to workers. Evidence from quasi-random job terminations, on the other hand, do suggest sizeable earnings drops for displaced workers, suggesting that different jobs are not perfect substitutes.

Assuming that there are positive rents in most employment relationships, Manning (2011) puts the ballpark estimate at 30%, an important question is how they are divided. Most empirical studies assume an efficient Nash bargaining solution between the firm and "labor," i.e. a trade union that acts as a bargaining agent for the workers. The firm cares about profits, the difference between a revenue function F(.) which is concave in the number of workers (L) and the wage bill. The union cares about the difference between the wage rate (w) and an exogenous reservation wage (b). There is a parameter α that represents the relative bargaining weight of labor.

The first order conditions of this maximization problem can be written as

$$w = \alpha \frac{F(L)}{L} + (1-\alpha)b \, .$$

The equilibrium wage will be the weighted average between the average productivity of a worker and the outside option of that same worker. The more bargaining power a firm has, the more it will be able to push the worker closer to her reservation wage.

A different way to write the last equation is as

$$w = b + \frac{\alpha}{1-\alpha}\frac{F(L) - wN}{L} = b + \alpha' \frac{\pi}{L} \, .$$

A worker is expected to receive her reservation wage plus a fraction of the profit per worker. If the worker's relative bargaining weight α' = α/(1-α) is higher, the wage will be higher as well. This formulation makes it clear that the observed rents obtained by the workers are endogenous to the wage rate. To estimate this profit sharing wage determination one needs an instrumental variable that exogenously moves profits around.

Table 4 in Manning (2011) surveys ten different studies and converts the different estimates to a comparable estimate for α. The estimates vary between 0.02 for industrial workers in Canada over the 1978-1984 period to 0.65 for unionized U.S. truckers around the time of deregulation of the industry. The average across the ten studies is 0.2, which suggests that the firms have the upper hand in the bargaining game and will be able to appropriate most of the rents (on average).

Two patterns are worth noting. First, in continental European countries where wage-bargaining is more centralized, the importance of workers on the firm-level wage-setting is estimated lower. This is as expected as firm-level variation will not be able to pick up the relevant exercise of the workers' bargaining power. Second, the estimated α parameter seems higher in non-union sectors. This might reflect reverse causality: unionization is a more attractive strategy in industries where firms happen to have better bargaining power..

The alternative approach to wage determination is wage posting by individual firms. This can be viewed as a take-it-or-leave-it offer by the employer, which is an extreme case of the previous bargaining model—it corresponds to a value of zero for the earlier α parameter. However, in practice the exercise of bargaining power by firms will not be absolute even in this case as workers are likely to be heterogeneous in many respects. This can be straightforwardly incorporated in the analysis by an upward-sloping labor supply curve for individual firms.

A monopsonist firm—with respect to this residual supply curve—will set a wage using the standard first order condition (the monopsonist alternative to the Lerner equation of a monopolist):

$$w = \frac{\varepsilon(w(p))}{1 + \varepsilon(w(p))}\, p\ .$$

Here, worker productivity is indicated by p and the residual labor supply elasticity will generally be endogenous, which is made explicit by making it a function of the wage and indirectly the productivity level. Implicitly, this model assumes that $p>b$. The firm will only be in business if productivity exceeds the reservation wage.

Table 6 in Manning (2011) summarizes quasi-experimental evidence on the size of the relevant elasticity in the above equation using job separations induced by exogenous policy changes. The absolute magnitudes across six studies vary between 1.4 and 4.3 with only a single study finding a negative point estimate, which is not statistically significant.

Table 7 of the same paper collects non-experimental evidence from a total of 17 studies. By and large, the estimates are even lower than the experimental evidence with not a single study finding an elasticity higher than two. This evidence strongly indicates that worker mobility is not very sensitive with respect to the wage rate. To know the actual degree of market power that this gives to employers one also needs to know the recruiting elasticity, i.e. the responsiveness of the net vacancy fill rate to employers' expenditures on recruiting (including advertising positions and screening candidates). In equilibrium, the recruiting elasticity is a function of the workers' labor supply elasticity, the separation rate for existing job matches, and the matching technology for open vacancies. The evidence is at least suggestive that firms do have some market power in the labor market even assuming that workers are heterogeneous.

While many of the studies use sectoral data, some of the micro-level studies point to further interesting patterns. Brummund (2012) finds that there is a lot of heterogeneity in the extent of firms' market power. Half of the Indonesian establishments in his sample have a significant amount of market power and characteristics of the individual firms are much better predictors than local labor market conditions.

One variable that influences the above estimates is the inclusion or exclusion of job tenure. Inclusion of this variable always lowers the estimated elasticity, but there are theoretical arguments both in favor and against controlling for it. In the presence of endogenous seniority wage scales, the apparent relationship between separations and wages could be spurious. Ransom and Oaxaca (2010) control for the endogeneity of wages with seniority by using contractual wages for a job. The estimates they find are in the middle of the overall range: 1.6 for male and 1.3 for female workers.

7.2 Productivity and wage premiums associated with worker characteristics

In addition to the average remuneration of workers, we are also interested in the relationship between remuneration and productivity for individual characteristics. One reason is that many worker characteristics such as schooling, training, job tenure, are the outcome of actual decisions and it is important to get investment incentives right. If the returns to human capital are not in line with their productivity effect, we will get under or over investment. Another reason is that there have historically been important instances of discrimination in the labor market. Fryer (2011) reviews the historical evidence and provides a modern perspective on race discrimination and Bertrand (2011) does the same for gender.

A very large literature has reported estimates of Mincer wage regressions in a variety of countries and settings. Results are used to assess the importance of several aspects of human capital. Heckman, et al. (2006) focus in particular on the returns to schooling and Appleton, Hoddinott, and Mackinnon (1996) survey the evidence on schooling and health in African countries. The focus in this literature has been on estimating the wage premiums as accurately as possible. The main challenge has been to explicitly account for ability bias which is correlated with both human capital investments, such as schooling, and the wage rate.

Fox and Smeets (2011) have approached the subject from the production side. They verify whether accounting for worker heterogeneity reduces the observed variability in plant-level productivity estimates. Their estimates suggest that even though several human capital characteristics have a significantly positive impact on productivity, controlling for them only moderately reduces observed variation in productivity.

A particularly relevant strand in the literature is the measurement approach proposed by Hellerstein, Neumark, and Troske (1999). They jointly estimate a production function that incorporates a heterogeneous labor aggregate and a wage equation at the plant level. It allows them to verify not only whether a certain worker characteristic is well-remunerated, but they can even compare the absolute magnitude of the wage premium with the productivity premium that is associated with the same worker characteristic. Their overall conclusion is that

> *"With one major exception [discussed below], our basic results indicate that for most groups of workers wage differentials do, in fact, match productivity differentials. (Hellerstein, et al. 1999, p. 443)"*

A number of other studies have also used matched employer-employee data to observe average worker characteristics by firm and to estimate both wage and productivity premiums. In principle, firm or plant-level data sets with extensive information on the workforce are sufficient (see for example Konings and Vanormelingen, 2010), but this is also quite rare. A conference symposium in the

Monthly Labor Review in July 1998 and various chapters in the book by Haltiwanger et al. (1999) provide an overview of data sources in different countries.

From a sub-sample of a firm's employees, one can already estimate the average value for various worker characteristics and then jointly estimate a wage equation and production function. Hellerstein et al. (1999) pioneered the approach using U.S. administrative record information. They formally test for equality of the two premiums for a number of characteristics and only find a statistically significant discrepancy for the gender dummy. Women are estimated to be only 16% less productive than their male co-workers, a difference that is statistically significant, but no explanation is advanced. The difference between male and female workers is even a lot higher in the wage equation: women are on average paid 45% less.

The first panel (a) in Table 1 contains these results. While cautioning that their estimates are not the decisive test for discrimination in the labor market, they do conclude that this evidence is considerably more convincing of the presence of sex discrimination in the US labor market. With the exception of the gender dummies, the other productivity and wage premiums are estimated remarkably close. Note for example that black workers appear to have an productivity advantage over the outside category of all other ethnicities (white, Asian, Hispanic, etc.) of 18%. This difference is insignificant, as the standard error for the point estimate is 0.14, and moreover it is matched by a comparable wage premium of 12% for black workers after controlling for a host of control variables and other worker characteristics.

Table 1: Productivity and wage premiums for different worker characteristics

	Productivity	Wages	p-value for equality
(a) Hellerstein et al. (1999), U.S. manufacturing, 1990 WECD			
Male	0.16	0.45	0.00
Black	0.18	0.12	0.63
35-54 year	0.15	0.19	0.71
55+ year	0.19	0.18	0.95
Ever married	0.45	0.37	0.68
(b) Hellerstein and Neumark (2007), U.S. manufacturing, 1990 DEED			
Male	0.211	0.383	0.00
Black	-0.084	0.003	0.05
35-54 year	0.108	0.210	0.00
55+ year	-0.135	0.128	0.00
Ever married	0.103	0.119	0.72
Some college	0.481	0.354	0.00
Managerial/professional	0.224	0.218	0.90
Technical, sales, etc.	0.337	0.259	0.07
Precision production, craft, etc.	0.130	0.111	0.61
(c) Crépon et al. (2003), France manufacturing			
Male	0.112	0.138	p>0.10
Unskilled	-0.145	-0.148	p<0.01
Highly skilled	0.571	0.475	p<0.01
Entry age (age < 25)	-0.084	-0.214	0.01<p<0.05
Young (25 < age < 35)	0.109	-0.031	p<0.01
Older (age > 50)	0.011	0.105	p>0.10
(d) Konings and Vanormelingen (2010), Belgium			
Training – manufacturing	0.0032	0.0032	0.07
Training – non-manufacturing	0.0047	0.0032	0.00

	Productivity	Wages	p-value for equality
(e) Van Biesebroeck (2011), sub-Saharan Africa manufacturing			
Experience – Tanzania	-0.027	0.016	0.00
Experience – Kenya	-0.009	0.013	0.04
Experience – Zimbabwe	0.013	0.008	0.58
Schooling – Tanzania	0.002	0.044	0.16
Schooling – Kenya	0.018	0.059	0.13
Schooling – Zimbabwe	0.072	0.073	0.99

The second panel (b) in Table 1 provides a cautionary note to the earlier results. Hellerstein and Neumark (2007) constructed a more reliable data set and repeated their analysis of U.S. manufacturing establishments. A few of the findings are unchanged, but equality of the productivity and wage premiums can now also be rejected for the two age categories. Middle-aged workers are more productive than younger workers, but not enough to justify their 21% salary premium. Older workers still enjoy a sizeable wage premium over younger ones, even though their productivity is lower. There is also some evidence that the college wage premium does not fully reflect the productivity advantage, but partly this might be due to a higher proportion of young workers with some college.

The evidence in Crépon et al. (2003) confirms the over-remuneration of older workers using data for France. Workers are classified into four age categories and the gap between the wage and the productivity premium is notably increasing in the age. The workers in the youngest category (less than 25 years old) are 13% underpaid, while the oldest workers (above 50 years old) are 9.4% overpaid, always relative to their respective productivity levels. In a study for Norway, Haegeland and Klette (1999) also finds that the productivity premium for workers with 8 to 15 years of experience exceeds the wage premium, while the opposite is true for workers with more than 15 years of experience.

Apart from the age premiums, the bulk of the evidence for developed countries points towards equal wage and productivity returns for various worker characteristics. In Hellerstein and Neumark (2007), the ‘some college’ variable only attracts a 43% wage premium while productivity is 67% higher, but this difference is not extreme. Approximately three quarters of the productivity benefit is reflected in the wage. The estimates for France and for Israel (in Hellerstein and Neumark, 1999) do not indicate any gender discrimination, although engineers are underpaid in Israel. For Norwegian workers, in the same Haegeland and Klette (1999) study, the wage premiums for both gender and education are in line with productivity premiums.

The return to training has received special attention in this literature. Konings and Vanormelingen (2010) measure training in average number of hours per worker and the premiums are shown in panel (d) of Table 1 for the manufacturing and for the service sector. The point estimates have extremely small standard errors and especially for firms outside the manufacturing sector equality can be decidedly rejected. Still, the wage premium captures more than two thirds of the total productivity effect of training.

Dearden, Reed, and Van Reenen (2006) focus on the effects of training using an industry-level data set for the U.K. manufacturing sector. They separately estimate wage equations and production functions and find that the productivity effect of training substantially exceeds the wage effect, but no formal test is presented. They conclude that the usual approach in the literature of quantifying the benefits of training by looking at wages underestimates its impact. One reason they point to is that aggregation to the industry magnifies the productivity benefit of training, potentially due to externalities. It is not surprising then that wage premiums do not capture the full benefits of training.

Only a few studies exist for developing countries. Jones (2001) estimates a firm-level production function jointly with an individual level wage equations for Ghana, but gives no details on the estimation. She finds that women are 42% to 62% less productive, depending on the specification, but paid only 12 to 15% less. No formal test is reported, but the standard errors are fairly large. Her focus is on the premiums associated with an extra year of schooling, which are estimated similarly in the production function and the wage equation: both are around 7%. When discrete levels of education attainment are used, the results are ambiguous. The differences in point estimates are large, but the education coefficients in the production function are estimated very imprecisely. None of the formal tests indicate a statistically significant difference although many are large in absolute value—five of the eight estimated premium differentials exceed 20%.

Bigsten et al. (2000) gauges the link between wages and productivity indirectly, similar to the U.K. analysis in Dearden et al. (2006). First, they estimate the returns to education in five sub-Saharan countries using a wage equation. Then, they separately estimate the production function, including lagged levels of education as a proxy for human capital. They find that the implied rate of return to human capital is very low, in particular it is only a fraction of the return to physical capital.

Van Biesebroeck (2011) estimates wage and productivity premiums for three sub-Saharan African countries that are clearly ordered in terms of level of development: in order, Tanzania, Kenya, and Zimbabwe. Three findings stand out. First, equality of the wage and productivity premiums is much more likely to be rejected in the poorer country (Tanzania) than in the richer (Zimbabwe). The country with an intermediate level of development (Kenya) is also intermediate in terms of equality of wage and productivity premiums. The p-value for the joint test of equality for labor market experience and numbers of years of schooling rises with the level of development from 0.01 to 0.09 and to 0.82. The same equations are estimated separately for two cities within each country and equality was always holding better in the more economically more developed agglomeration. The sample size of jurisdictions is very small, but it is suggestive evidence that labor markets work more efficiently in countries and cities with a higher level of development. It is unknown which way the causation runs if the link is causal.

A second insight is obtained from the way in which equality fails to hold. The wage return with respect to experience and schooling is fairly robust in all three countries. The discrepancies are much more pronounced on the productivity side. In Tanzania, firms with older workers achieve lower productivity even though they place a positive wage premium on labor market experience. Similarly, even though firms with more educated workers do not produce any more output, salaries rise by 4.4% with each year of schooling. The wage returns to experience and schooling are comparable in Kenya—respectively a fifth lower and a third higher than the premiums in Tanzania—but the productivity premiums are notably different: 1.8% and 1.6% higher productivity for each year of experience or schooling. The same pattern is true comparing with Zimbabwe.

Third, rejections of equality only appear for general human capital characteristics, i.e. labor market experience (similar to age) and formal education. For firm-specific attributes of human capital, i.e. firm-specific job tenure and on-the-job training, equality cannot be rejected in any of the three countries. The difference is especially stark in the two least developed countries. While they both overpay older and more educated workers, the reverse is true for tenure and training. These last two variables are always associated with positive productivity benefits, but the wage premiums are quite a bit lower. Such a reward system makes it likely that workers will overinvest in schooling and underinvest in training.

There is some debate whether to include occupation controls in the above regressions. In some cases researchers have included them to make comparisons more narrow and reliable. In other cases they are omitted as access to an occupation can exactly be the way in which one realizes a return on education or another human capital characteristic. A recent paper by Lazear, Shaw, Stanton (2012) looks at the value of "bosses" more generally and Chetty et al. (2011) find that kindergarten teachers similarly generate much more value than they are able to capture in their salaries.

Older workers:

In a dynamic perspective of the labor market there are several reasons why it might make good sense to pay older workers a seniority premium, even in excess of their productivity contribution. Bolton and Dewatripont (2005) formally describe several models with this feature.

In career concern models, the employer makes income a deterministically increasing function of tenure to induce high effort. Early on in a worker's career, high future pay works well as a motivator, but as a worker's remaining time horizon shrinks delayed pay becomes less effective to induce effort. A related benefit of such a salary structure is the ability to tie a worker to a particular employer and preserve firm-specific human capital. When much of human capital is acquired on-the-job rather than through formal education it is efficient to invest intensively in skill acquisition early in a worker's career when the remaining time to reap the benefit is large. The return on investment is realized later on, even when worker effort (and productivity) might be lower. Another way for the employer to realize a return on the human capital of older workers is through their involvement in training newly hired staff.

All of the above benefits of higher wages for older workers, even in the absence of a productivity gradient with age, become less relevant if the nature of work changes. Evidence suggests that job tenure has declined, see for example Bernhardt et al. (1999), which makes it less effective than before to motivate workers with delayed pay. The trend towards globalization of work and ongoing disappearance of manufacturing jobs—where historically job tenure was higher—makes workers expect that this trend will continue. The waning influence of unions in the private sector also reduces the benefits of a seniority wage gradient. It even puts firms that still practice it at risk of seeing their best young workers poached away by competitors.

More on developing countries:

An issue of particular importance to developing countries is a low labor supply elasticity induced by bad outside options. A first incarnation of this problem was already highlighted in the discussion of the results in Van Biesebroeck (2011). In less developed economies there was a larger gap between the marginal productivity and remuneration associated with human capital characteristics. This was even true within countries, possibly due to importance of localized labor markets. A bad bargaining position of workers can lead to wages that fall far short of marginal productivity.

Jayachandran (2006) highlights another negative feature of the low labor supply elasticity by exploiting time-series evidence for India. She shows that negative productivity shocks have a greater effect on wages if workers are poorer, are less able to migrate, and are more credit-constraints. Each of these three characteristics is also associated with a less elastic labor supply elasticity. This evidence comes from truly random productivity shocks for agricultural workers generated by variations in rainfall. The limited ability of workers to substitute towards other activities in the face of adversity lowers their welfare. In contrast, it provides insurance for landowners.

Complementary evidence for Brazil in Mueller and Osgood (2009) suggests that adverse short-term shocks can even have long-term effects. Droughts are found to lead to income shocks that could take affected workers five years to recover from. If households do not have a strategy to diversify their income streams, negative productivity shocks can lead to negative investments that deplete productive assets. This trade-off between insurance and effort provision, as reviewed in Malcomson (1999), calls for different solutions depending on workers' outside options.

7.3 The economy of superstars, rising inequality and dual labor markets

The question of the link between wages and productivity is also related to the literature on the economy of superstars and rising income inequality. In a seminal contribution, Rosen (1981) highlighted that in many disciplines, especially entertainment related ones, a handful of individuals now vastly out-earn everyone else. This is in spite of most (labor) markets now being larger than at any time before. What generates this outcome in his model is the nature in the assignment of buyers to sellers, which produces convex returns. Small differences in talent produce vast differences in returns in a winner-takes-all competition. Since the writing of his article, the network effects associated with name recognition and low distribution costs of the internet have probably strengthened these tendencies in the new economy.

Another trend that increases the disparity between remuneration of high and median income workers is the polarization of the U.S. labor market (Autor, Katz, and Kearney, 2006), which has been confirmed for Europe (Goos, Manning, and Salomons, 2009). Workers in the middle of the income distribution are often performing relatively routine tasks, which can increasingly be offshored to emerging countries, such as India, or automated away. While the average productivity of any remaining employees is unchanged, at the margin it becomes easier to substitute workers with computers or with offshored labor and it puts downward pressure on wages.

An important feature of the trend of rising wage inequality is that inequality has increased both across as well as within worker types. The wage difference is not only increasing between entrepreneurs and employees, between superstars and runner-ups, between workers performing non-routine and routine tasks, it is also increasing for observationally similar workers, even between workers employed at the same firm. The inequality in the wage residual—after controlling for observable worker and employer characteristics—has thus increased over time.

Katz and Autor (1999), for example, find that at least two thirds of the increase in earnings inequality is found in residual inequality. It is slightly less important for men, but noticeably more for women. Quite remarkably, in their 93 pages long survey article they do not discuss anywhere the link with labor productivity. Dunne et al. (2004) show that the increased dispersion in earnings residuals is foremost an establishment, not an industry-level phenomenon. They also show that it coincides with an increase in the plant-level productivity dispersion. Finally, a significant fraction of the rising dispersion in wages and productivity across plants is accounted for by changes in the distribution of computer investment.

Dual labor markets have been studied extensively in developing countries. In advanced economies, the gradual unwinding of labor regulation has also introduced a type of dual labor market for essentially the same work, which has weakened the link between wages and productivity.

As the governments of Spain, Portugal, or Italy have sought to reduce unemployment they have created parallel "insider" and "outsider" labor markets, where existing workers retained most of their employment protection and working conditions, while new workers are often hired under different rules. Such dual labor markets impose most of the adjustment on a limited set of workers. Even if the proportion of fixed duration contracts in total employment remains small, their introduction and development completely changes the labor market for young workers. Blanchard and Landier (2002) further document that the increased likelihood of fixed term versus indefinite duration contracts had carry-on effects. It lengthened the time it took workers to transition from unemployment into steady employment from 4.8 to 8 years. Young workers had to endure several more job terminations, often not because of inadequate performance, but simply because employers did not want to give up the flexibility that fixed duration employment contracts provided. In this process valuable firm-specific human capital is destroyed, young workers risk losing their attachment to the labor market and the diminished bargaining position of young workers also shows up clearly in lower wages.

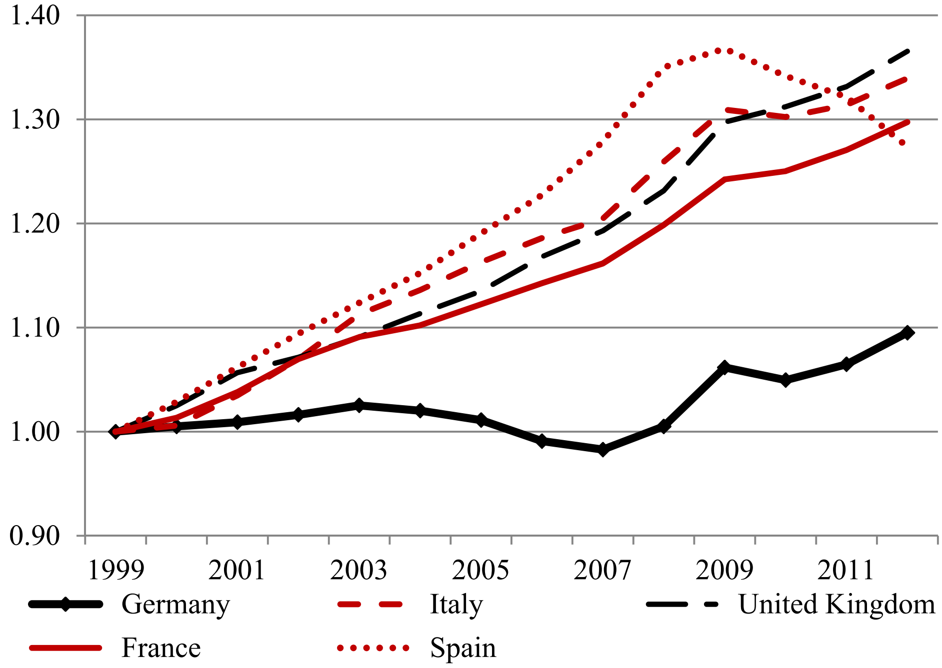
In the United States, Noble (1985) describes the dual pay scales that Pan Am Airlines instated in 1985. More recently, American automobile companies opened the door to lower pay for newly hired workers as a temporary measure. In some instances, workers under both types of contract work side by side, doing the same jobs, but the hourly wage of newly hired workers is approximately half that of incumbents. In 2011, 12% of Chrysler's workforce received the lower contractual wages (Vlasic, 2011). At Ford, which did not pass through bankruptcy, the current contract stipulates that up to 20% of its workforce could be employed at lower-tier wages before workers need to move up. Van Biesebroeck (2009) discusses the importance of the existence different bargaining regimes in the U.S. for the organization of the U.S. automobile industry and the fortunes of the American firms.

7.4 Time series evidence at national level: comparing growth rates

A comparison of the growth rates in wages and productivity can be carried out at different levels of aggregation, from individual workers to the national level. An important finding of the Global Wage Report 2012-13 (ILO, 2012) was the notable decline in the share of GDP going to labor income in many countries. The OECD (2012) has calculated that the median share among its member countries declined from 66.1% in 1990 to 61.7% in 2009. The share declined in 26 of the 30 countries for which data was available. Given that GDP, by definition, equals the sum of all value added in the economy, a declining share of aggregate wages to GDP means that average wages are not keeping up with average productivity. Note, however, that it does not necessarily say anything about what happens at the margin, whether or not wages have fallen below marginal productivity.

Unit labor costs, an index that tracks the evolution of wages divided by average productivity, has become a Eurostat statistic that has gained prominence during the euro crisis and recession. In Figure 2 we illustrate the evolution of this measure since the introduction of the euro in 1999 for the five largest EU members. The sharp divergence between Germany and the other countries is especially remarkable. Since the recession in 2009 the trend has reversed sharply in Spain, but not in the other countries. Note that the use of a separate currency by the United Kingdom gives it additional flexibility to adjust its economy in nominal terms. The 15% depreciation of the British pound relative to the euro reduces the real increase in unit labor costs relative to Germany to approximately 10%. The other countries do not have the same flexibility anymore.

Figure 2: Evolution of unit labor costs (nominal)



Source: Calculated based on Eurostat statistics.

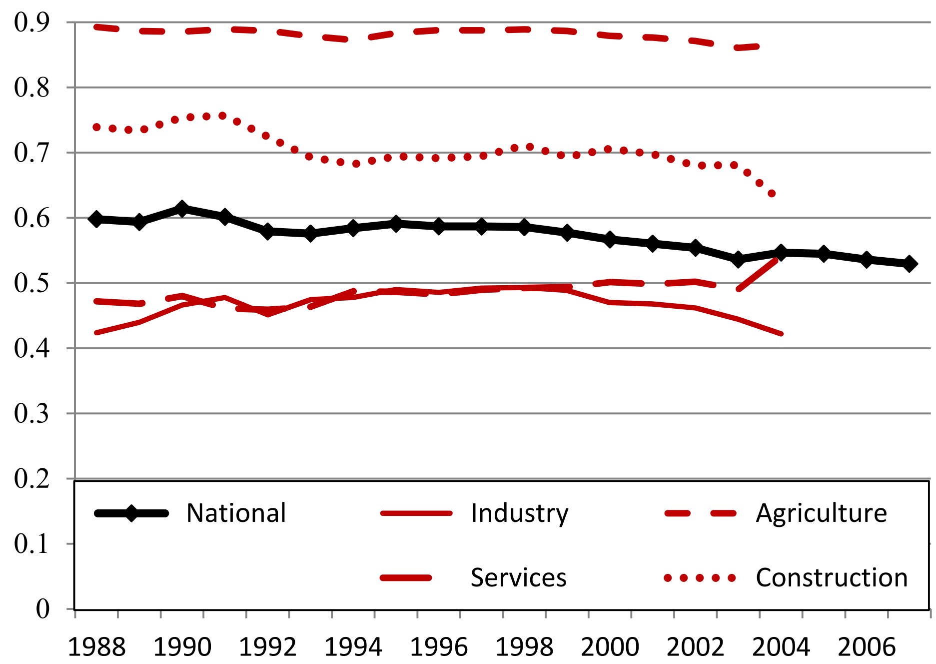
In developed countries, media reports often conjecture that this decline is a result of increased globalization and downward wage pressure from competition with low-wage countries. Freeman (1995) famously wrote "Are your wages set in Beijing?" Back in 1995 he concluded, however, that we lacked solid evidence that trade was behind the immiseration growth for low-skilled workers in developed countries. Recently, the topic of the effect of trade on wages has received renewed attention. The offshoring boom and the academic work on trade-in-tasks (Grossman and Rossi-Hansberg, 2008) as well as the spectacular rise of China as a trading nation has re-focused the attention of labor economists on the effects of international trade. The Global Wage Report 2012-13 (ILO, 2012) identified a variety of causes, including globalization, financialization, technological change, and a decline in the bargaining power of workers.

However, a puzzling pattern is that the labor share in national income is also declining in many developing countries, including in China. This is particularly remarkable as China is one of the few countries with relatively labor-intensive exports, which is even rising as exports grow (Ma, Tang, and Zhang, 2011). Moreover, China has experienced extremely rapid increase in salaries. Brandt et al. (2012a) find that the increase in wage per worker even outstripped labor productivity growth. Opposing this is a trend towards higher compensation of management and entrepreneurs which could be captured as operating surplus or profits of self-employed individuals and not show up in labor compensation.

Bai and Qian (2010) investigate the evolution of the Chinese wage share in detail. They start from the official statistics which reveal a precipitous decline by 12.5% between 1995 and 2007. However, almost half of this decline can be traced to an accounting change in the treatment of the operating surplus of state-owned and collective-owned farms and the mixed-income of rural households in the individual economy. Previously these components were treated as labor income, but China's National Bureau of Statistics reclassified them in 2004 as operating surplus.

When correcting for various other data problems as well to construct a series that is consistent over time, their best estimate is a decline in the aggregate labor share in national income from 61.4% in 1990 to 52.9% in 2007. This is still a decline by one seventh. Calculating the wage share by sector reveals the two main underlying trends—see Figure . First, the decline was particularly pronounced in the construction sector, followed by industry which accounts for a much larger share of employment than in developed countries. Second, the structural transformation of the economy, as workers move from the highly labor-intensive agriculture sector to other sectors, also contributed to the decline of the aggregate share. Approximately 40% of the aggregate change is due to within-sector changes in the labor share and 60% is due to labor movement between sectors.

Figure 3: Evolution of the labor share in national income for China



Source: Bai and Qian (2010)

Focusing on the change in labor share in industry, the authors do not find significant effects from shifts in relative prices, in the factor input ratio, or biased technological change. Factor substitution in industry is close to unitary elastic. The restructuring of the state-owned enterprises in the 1990s, which used to pay workers more generously, was an important factor. They also point to an expansion of monopoly power which increased the share of profits in national income. While this might be true for the (expanding) service sector, Brandt et al. (2012b) find that trade liberalization surrounding China's entry into the WTO in 2001 restrained or even reduced market power in the manufacturing sector. Sectors that experienced the largest decline in tariff rates, also experienced a statistically significant increase in the share of labor in value added.

Conclusion

To calculate labor productivity, one simply divides output by labor input. This can be done in several ways. Part A of the paper has provided an overview on how labor productivity is generally computed, highlighting measurement problems and challenges. A number of issues are discussed that are likely to be of particular relevance to developing countries. The importance of the informal sector and systematic undercounting of inputs are two such examples.

The second part of the paper, Part B, surveys the theoretical and empirical evidence on the relationship between wages and productivity. The competitive model of a spot labor market predicts that all workers will be remunerated at the marginal productivity of the market-clearing worker. We discuss how worker heterogeneity has been incorporated in this model and how asymmetric information, idiosyncratic matching, and institutions will lead to deviations from the simple benchmark. The empirical evidence on the observed relationship is reviewed afterwards.

There are three principal means for assessing the tightness of the link between wages and productivity. One strand of the empirical literature provides indirect evidence by looking at the labor supply elasticity with respect to the wage level. Both experimental and real world evidence suggests that employers do have monopsony power that they can use in principle to pay workers below their marginal productivity. The low recruiting elasticity, on the other hand, limits the extent to which firms can depress wages. Secondly, the empirical evidence on the remuneration of particular worker characteristics shows that in various settings the wage-productivity relationship breaks down. Firms, for example, do not seem to arbitrage between older and younger workers. On the evidence, young workers appear to be systematically compensated below their productivity level. This pattern does make the existence of large youth unemployment even more of a puzzle. The falling share of labor in national income over time provides a third window on the empirical link between wages and productivity. This evolution has been linked to the increased importance of entrepreneurship and human capital relative to pure labor input. While in the end all income necessarily accrues to individuals, knowledge workers and entrepreneurs might increasingly receive their reward as profit or return on capital.

Finally, we list a number of reasons why wages and productivity are more likely to diverge in developing countries. Greater measurement problems can be a first reason, but even the actual gaps might be larger as arbitrage forces do not work as well in volatile environments. Localized geographic markets might isolate different labor market segments. Distortions in one market, e.g. credit constraints or political interference in credit provision, can have repercussions in the labor markets as firms adjust. High price inflation makes it harder to equalize marginal returns and costs unless parties are willing to incur excessive contracting costs and renegotiate regularly. Rapid economic development, for example in China, also makes it harder to equate returns to the firm and the worker of investments in human capital that have an uncertain return that occur mostly in the distant future. While we found only limited violations of equality between wage and productivity in the literature, it would be valuable to see more work along this line specifically focusing on developing countries.

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