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Do labour market reforms reduce labour productivity growth? A panel data analysis of 20 OECD countries (1960–2004)

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Abstract. *Based on comprehensive regression analysis, the authors find that weak wage growth and a smaller labour share of national income significantly reduce labour productivity growth. They conclude that supply-side labour market reforms have contributed to reducing labour productivity growth: this cannot be explained by a deregulation-induced inflow of low-productivity labour as proposed by OECD researchers. They also discuss why deregulation, easier firing and higher labour turnover may damage learning and knowledge accumulation in companies, notably by weakening the functioning of the "routinized" innovation model ("Schumpeter II"). Finally, their findings raise doubts about the relevance of Baumol's law and Verdoorn's law.*

With the emergence of supply-side thinking in the 1970s, the claim that high (European) unemployment is caused by "rigidities" in labour markets became dominant. The usual suspects are high minimum wages, high social benefits, strong trade unions, the power of insiders and strong protection against firing. Claims about the beneficial effects of removing such "protective labour market institutions" (Howell et al., 2007) tended to be made under the (often implicit) assumption that this would not affect innovation or productivity growth. This assumption tended to be easily accepted because it was in line with the old belief that technological change is "manna from heaven".

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In this article, by contrast, we argue that deregulation of labour markets and removing "labour market rigidities" definitely do have a price. They are intended to bring down wage costs and weaken the bargaining position of labour, which can also result in more precarious jobs (see, for example, Carlin and Soskice, 1990; Layard, Nickell and Jackman, 1991; Rowthorn, 1999). Moreover, we argue that labour market rigidities can be useful for innovation, notably for the workings of what is often called the "routinized" ("Schumpeter II") innovation model (see Breschi, Malerba and Orsenigo, 2000).

The "rigidity of labour markets" argument has had a powerful influence on policy-making. Many countries have taken steps towards making their labour markets more flexible, and this has not been without consequences. For example, a firm-level analysis by Lucidi and Kleinknecht (2010) shows that (after a series of labour market reforms) Italian firms which made use of new regulations for employing (cheaper) flexible labour showed significantly lower rates of labour productivity growth than (similar) firms that did not avail themselves of the new regulations.

Accordingly, in our country-level analysis, we assume that measures aimed at removing labour market rigidities will ultimately result in a more modest wage growth. Using a panel of 20 OECD countries, we analyse the impact on labour productivity growth of changes in wages and of shares of labour income in GDP over the period 1960–2004. We find that all 20 countries experienced a decline in labour's share of national income as from the 1970s. In other words, real wage increases tended to remain below the rates of labour productivity growth. While this certainly reflects the weaker power of trade unions due to higher unemployment since the mid-1970s, it may also reflect the growing influence of the labour market rigidities view in practical policy-making.

The remainder of this article is organized into four sections. The first two present theoretical arguments as to why we expect deregulation of labour markets to influence productivity and innovation, followed by a review of previous empirical findings and hypotheses. The third section presents our estimates, and the fourth rounds up with conclusions.

Theoretical arguments

The literature distinguishes three categories of "flexibility" (e.g. Beatson, 1995), namely:

- "Numerical" (or external) flexibility that allows firms to adjust the size of their labour force through flexible hiring and firing;
- "Wage flexibility", which centres on the responsiveness of wages to economic shocks; and
- "Functional" (or internal) flexibility that allows firms to reorganize their workforce in internal labour markets through training and human resource management policies.

Emphasis on the first two types of flexibility is characteristic of the Anglo-Saxon liberal market economies, whereas coordinated market economies (or “Rhineland systems”) rely more on functional flexibility (Albert, 1993; Hall and Soskice, 2001). There is evidence from firm-level data that high functional flexibility in internal labour markets may be favourable to innovation and productivity growth (Appelbaum et al., 2000; Bassanini and Ernst, 2002; Michie and Sheehan, 2001 and 2003; Kleinknecht et al., 2006; Zhou, Dekker and Kleinknecht, 2011). The policy agenda aimed at removing labour market rigidities, however, is mainly concerned with wage cost-cutting numerical flexibility and with (downwardly) flexible wages.

Institutional reforms that procure more flexible wages and those allowing for easier firing both work in the same direction: they allow savings on a firm’s wage bill. In principle, workers who accept a flexible job should earn a positive risk premium that compensates for the higher risk of being fired. Empirical evidence, however, suggests that the opposite appears to be the case (Sànchez and Toharia, 2000; Booth, Francesconi and Frank, 2002; Mertens and McGinnity, 2004; Addison and Surfield, 2005; Picchio, 2006). Such evidence from individual-level wage equations is consistent with estimates of firm-level wage equations (Kleinknecht et al., 2006). Specifically, workers in flexible employment earn less on average than regular workers (controlling for other personal characteristics). A possible explanation is the abundant supply of labour in certain segments of the labour market. In the context of this article, it does not matter whether lower wage growth is caused by institutional changes in the wage-setting mechanism or the easing of firing conditions or other “rigidities” (e.g. regulations on minimum wages or social benefits).

In the following subsections, we discuss four major channels of transmission through which the removal of labour market rigidities translates into lower productivity growth, namely:

- Effects on innovative activity;
- Effects on training;
- Trust and productivity growth; and
- The impact of aggregate demand on productivity growth.

Although we have no data that would allow us to analyse the separate effects of each channel, we expect all four channels to reduce labour productivity growth. The literature on “varieties of capitalism”, however, suggests that the four channels are highly correlated (Albert, 1993; Hall and Soskice, 2001).

Effects on firms’ innovative activity

Three arguments substantiate a causal link from higher wages to higher labour productivity growth. First, one can argue that an increase in the price of labour relative to capital will stimulate the adoption of labour-saving technology. Second, from a Schumpeterian perspective, it can be argued that, due to their monopoly rents from innovation, innovators are better able than technological laggards to live with wage increases or with high adjustment costs due to stricter regulation. High real wage growth and higher adjustment costs resulting from labour market rigidities may thus enhance the Schumpeterian process of "creative destruction" in which innovators compete away technological laggards (Kleinknecht, 1998). Conversely, (downward) wage flexibility increases the latter's chances of survival. While their survival is good for employment in the short run, it is likely to result in a long-run decline of the average quality of entrepreneurship and a loss of innovative dynamism. Third, using vintage models, it is easy to demonstrate that more aggressive wage policies by trade unions will lead to quicker replacement of older (more labour-intensive) vintages of capital by new and more productive ones. A policy of modest wage claims will allow firms to exploit old vintages of capital for longer, possibly resulting in capital-stock ageing.[1]

Against such arguments, there are three counter-arguments. First, labour market rigidities could have negative effects on productivity by slowing down the reallocation of labour from old and declining sectors to new and dynamic ones (for a review of the effects of labour market institutions on economic performance, see Nickell and Layard, 1999). Second, if redundant workers are difficult or expensive to fire, this can frustrate labour-saving innovations at the firm level (Bassanini and Ernst, 2002; Scarpetta and Tressel, 2004). Third, a well-protected and powerful workforce could appropriate rents from innovation and productivity gains through higher wage claims, thus reducing incentives for taking innovative risks (Malcomson, 1997). While the latter argument might be quite relevant in decentralized Anglo-Saxon bargaining systems, it appears to be less relevant to rigid "Rhineland" labour markets that tend to rely on more centralized (often industry-level) wage bargaining.

The argument that the difficulty of firing workers will hamper labour-saving innovations might be less relevant for three reasons. Firstly, if firing is difficult, firms have incentives to invest in functional flexibility by means of training, which will allow them to shift labour from old to new activities in internal labour markets. Second, in many countries, redundant workers need not be a problem for labour-saving innovations because high percentages of them leave their firms voluntarily.[2] Third, protection against dismissal may actually enhance productivity performance, as secure workers will be more willing to cooperate with management in developing labour-saving processes and in disclosing their tacit knowledge to the firm (Lorenz, 1999). More generally, workers that are easy to fire have incentives to hide information about how their work might be done more efficiently, and in doing so, they can make use of information asymmetry between shop-floor and management. In other words, systems with easy firing are likely to make poor use of knowledge from the shop-floor for cost-cutting.

[1] This was shown to be one of the reasons behind the productivity crisis in the Netherlands after 1985 (see Naastepad and Kleinknecht, 2004).

[2] Kleinknecht et al. (2006) report that, on average, 9–12 per cent of a firm's workforce leave voluntarily each year in the Netherlands, the exact percentage depending on the state of the business cycle. Nickell and Layard report that this figure amounts to over 10 per cent (1999, p. 363).

Effects on workforce training

Easier firing leads to shorter average job tenure, thereby also shortening the payback period of investment in training. In addition, workers will be interested primarily in acquiring general skills that increase their employability on the external job market, but they may be reluctant to acquire firm-specific skills if they have no long-term commitment to their employers (Belot, Boone and van Ours, 2002). A similar conclusion emerges from the hypothesis that highly flexible labour reduces the compression of the wage structure (both within and between firms), which is a reason for the provision of training by firms (Acemoglu and Pischke, 1999; Agell, 1999). Empirical evidence of a correlation between fixed-term employment and a lower probability of work-related training in the United Kingdom has been provided by Arulampalam and Booth (1998) and Booth, Francesconi and Frank (2002).

Trust and productivity growth

Work by Huselid (1995), Buchele and Christiansen (1999a and 1999b), Lorenz (1999), Michie and Sheehan (2001 and 2003) and Naastepad and Storm (2006) shows favourable productivity effects of "high-trust" or "high-road" human resource management practices. Long-lasting working relations and strong protection against dismissal can be interpreted as an investment in trust, loyalty and commitment which favours productivity growth in three ways.[3] First, it reduces the costs of monitoring and control. For example, Naastepad and Storm show that firms in low-trust "Anglo-Saxon" countries typically have much thicker management bureaucracies for monitoring and control, compared to "Rhineland" countries (2006, pp. 170–191). Second, it reduces the leakage of knowledge to competitors. Third, it favours long-run historical accumulation of (tacit) knowledge in a "routinized" (Schumpeter II) innovation model (Breschi, Malerba and Orsenigo, 2000).

The impact of aggregate demand on productivity growth

Finally, easier firing can have negative effects on aggregate demand through increased precautionary savings by those who fear job loss. Bhaduri and Marglin (1990) have indeed argued that lower wages depress demand if an economy is "wage-led", rather than "profit-led". The so-called Verdoorn law proposes a positive impact of demand growth on productivity growth. In a different strand of literature, the Verdoorn law is paralleled by Schmookler's (1966) "demand-pull" hypothesis for patenting activity. Both suggest that, in so far as modest wage growth leads to lower demand, it may reduce the pace of innovation and productivity growth.

[3] On the relationship between working conditions and trust, see also Svensson (2012).

Previous empirical findings and hypotheses

Most empirical analyses of the relationship between labour flexibility and productivity growth tend to use country or sectoral data, searching for relationships between measures of labour market rigidity and productivity (Buchele and Christiansen, 1999a and 1999b; Nickell and Layard, 1999; Bassanini and Ernst, 2002; Scarpetta and Tressel, 2004; Auer, Berg and Coulibaly, 2005; Naastepad and Storm, 2006; Vergeer and Kleinknecht, 2011). Most of these studies observe a positive effect of employment protection (measured by the OECD index or other indicators) on labour productivity growth or innovation indicators. Auer, Berg and Coulibaly (2005) find a positive (though decreasing) relationship between job stability, measured as average tenure, and labour productivity. Scarpetta and Tressel (2004), however, find a negative effect of employment protection, mainly in countries with uncoordinated wage bargaining. Variation between the different industrial relations models is also considered by Bassanini and Ernst (2002), who assert that the strictness of employment protection legislation is significantly correlated to technological specialization in countries with coordinated relations.

A different approach is taken by Acharya, Baghai and Subramanian (2010), who study patents and patent citations as a proxy for innovation. They argue that stringent labour laws provide firms with a "commitment device" that leads them to refrain from punishing short-run failures, and this would, in turn, encourage employees pursuing risky and value-enhancing innovative activities. Examining time series variation in relation to changes in dismissal laws, they find that "innovation and economic growth are fostered by stringent laws governing dismissal of employees, especially in the more innovation-intensive sectors. Firm-level tests within the United States that exploit a discontinuity generated by the passage of the federal Worker Adjustment and Retraining Notification Act confirm the cross-country evidence" (ibid., abstract). Similarly, Pieroni and Pompei (2008) find a negative effect of labour turnover – as a proxy for external flexibility – on patenting activity in Italy.

Some studies report firm-level evidence. For example, Michie and Sheehan (2001 and 2003) find a positive correlation between "high-road" human resource management practices and innovation in British firms. Kleinknecht et al. (2006) find negative effects of external flexibility and positive effects of functional flexibility on labour productivity growth in a sample of manufacturing firms in the Netherlands. Arvanitis (2005) finds a positive relationship between functional flexibility and labour productivity in a sample of Swiss companies, but an insignificant effect of external flexibility. Autor, Kerr and Kugler (2007) find a positive effect of employment protection on capital investment, skills and labour productivity, but a negative effect on total factor productivity. Lucidi and Kleinknecht (2010) report estimates based on a sample of 3,000 Italian firms. They show that high proportions of flexible workers, high labour turnover and lower costs of labour (relative to capital) are each related to significantly lower rates of labour productivity growth. Boeri and

Garibaldi (2007) find a negative effect of the share of fixed-term contracts on labour productivity growth in a sample of Italian manufacturing firms during the period 1995–2000.

Many of the above findings and arguments (implicitly) assume that easier firing will result in higher labour turnover. One may object that statutory ease of firing does not per se *prevent* firms from keeping their workers for longer. However, one can also argue that the mere *option* of easy firing may increase mobility. Specifically, in a firm that is not doing well, employees may search for alternative jobs at an early stage. Once massive lay-offs take place, competition for jobs in the local labour market may increase dramatically. It is therefore of vital importance for individual workers to start their job search at a very early stage, before others become aware of the threat of lay-offs. Workers may therefore leave before their firm has even considered firing them.

While the findings reviewed above are concerned with changes in wages and in external flexibility, we now discuss four arguments as to why we expect the wage share in national income to have an effect on labour productivity growth.

Argument 1: A higher wage share is an incentive for firms to raise labour productivity

A high wage share in national income is the accounting equivalent of a high wage share in production costs. If the share of wages in production costs is higher, firms save more on the wage bill with any given savings on labour inputs. A higher wage share is thus an incentive to invest in raising labour productivity.

Formally, we can work this out by splitting a firm's production costs into components and factoring in growth rates (equations 1–3). Total production costs can be written as:

$$Xp = (WL + RK) \qquad (1)$$

where the costs of production (Xp) are split into labour costs (WL) and capital costs (RK). The latter component may also be seen as "profit income". Division by units of output (X) allows unit costs (p) to be written as:

$$p = (WL + RK) / X = W / \lambda + R / \chi \qquad (2)$$

where λ denotes labour productivity and χ, capital productivity.
If we rewrite equation 2 in growth rates, we obtain:

$$\hat{p} = -ws^{*}\hat{\lambda} - (1 - ws)\,\hat{\chi} \qquad (3)$$

where ws denotes the share of wages in total production costs.

In equation 3, the percentage reduction in costs is negatively proportional to the percentage growth of labour productivity. We note that, *ceteris paribus*, the partial derivative of unit costs with respect to labour productivity is a negative linear function of the share of wages. Thus, without any further assumptions on the relationships between the variables in equation 3, we find that a higher wage share raises firms' incentives to increase labour productivity.

Foley and Michl (1999, pp. 275–278) worked out in more detail the relationship between the wage share and incentives to invest in capital- versus labour-enhancing technological progress. They describe a model of induced technological change that carries the result that labour productivity growth is a positive non-linear function of the share of wages in total costs. They arrive at this conclusion by analysing the incentive structure facing individual firms in regard to labour productivity increases. This incentive structure follows from the distribution of labour and capital costs per unit of output, as given in equation 3.

Foley and Michl (1999) pose a firm's choice of investment in technological progress between labour- and capital-saving technology as the result of the following planning problem:

$$\min\,(-ws^{*}\hat{\lambda} - (1 - ws)\,\hat{\chi}) \tag{4}$$

This means that firms try to reduce unit costs as much as possible by increasing labour and/or capital productivity. To determine what is possible, Foley and Michl (1999) assume a technological progress function (equation 5) that features a trade-off between the growth of labour productivity and the growth of capital productivity.

$$\hat{\chi} = f(\hat{\lambda});\ \text{where } f';\ f'' < 0 \tag{5}$$

$f' < 0$ denotes that the path of technological progress exhibits a trade-off between growth of labour productivity and growth of capital productivity. Furthermore, a large increase in labour productivity requires a proportionately larger fall in the increase in capital productivity ($f'' < 0$).

If we substitute equation 5 into equation 4, we can express the entrepreneurial planning problem as follows:

$$\min\,(-ws^{*}\hat{\lambda} - (1 - ws)\,f(\hat{\lambda})) \tag{6}$$

with the corresponding first order condition:

$$d\,(-ws^{*}\hat{\lambda} - (1 - ws)\,f(\hat{\lambda}))\,/\,d\hat{\lambda} = (0) \tag{7}$$

and thus:

$$f'(\hat{\lambda}) = -\frac{ws}{(1 - ws)} \tag{8}$$

If we fill in an appropriate technological progress function in equation 8 (i.e. with $f' < 0$), we end up with a non-linear, positive relationship between the wage share and the growth of labour productivity.[4]

Argument 2: The wage share is an indicator of the fairness of income distribution

Fairness is a notion that appears frequently in business decisions (Freeman, 2005). The higher the share of wages in national income the more likely it is

[4] It is conceivable that $f' < 0$, i.e. the entrepreneur can invest in developing a technology that is both labour *and* capital saving. In this case, equation 4 becomes insolvable as there is no minimum. However, the general result still holds. That is: the entrepreneur has a higher incentive to invest more in a technology that is relatively more labour saving if the wage share is higher.

that workers will perceive their income as fair. In a series of papers, Akerlof and Yellen have found evidence that pay equality promotes teamwork and that work-group effort norms depend on the perceived fairness of pay and pay differentials (Akerlof, 1982 and 1984; Akerlof and Yellen, 1986 and 1990; see also Buchele and Christiansen, 1999a and 1999b). In other words, higher wage shares in national income may enhance efforts to improve productivity growth.

Argument 3: The wage share is a measure of labour's stake in productivity growth

With a higher wage share, workers have a stronger motivation to contribute to productivity growth. Workers' contribution is important, as many productivity-enhancing ideas stem from their experience on the shop-floor. And the implementation of process innovations often depends crucially on the collaboration of workers and their disclosure of "tacit" knowledge gained through experience (Lorenz, 1999).

Argument 4: Low-trust labour relations impede efficiency

The literature on varieties of capitalism suggests that a more unequal income distribution – i.e. a lower share of wages in national income – tends to correlate with "low-road" human resource management practices, such as easy hiring and firing. If workers are easy to fire, not only do they have strong incentives *not* to disclose their "tacit" knowledge for the implementation of labour-saving investments, but they also, more generally, have an incentive to hide information about how their work could be done more efficiently, making use of information asymmetry between management and shop-floor. Wider income inequality may thus indicate low-trust labour relations in which management makes poor use of the knowledge from the shop-floor for implementation of more efficient work practices.

Regressions

Following van Schaik and van de Klundert (2013), we use five-year average values, calculated from data roughly spanning the period 1960–2004. Five-year averages eliminate short-run fluctuations in the data; and we control for fluctuations of longer duration by including time-dummies in the regression. As we use contemporaneous independent variables, we work with instrumented variables that have appropriate lags (more on this below) in order to avoid endogeneity problems.

In explaining labour productivity growth, our two key independent variables are annual wage growth and the share of wages in a country's GDP (both are expected to have a positive sign). As control variables we use:

- *Catchup*, to control for catching-up effects due to spillovers that depend on the size of the gap between the given country and the technologically leading country (expected to show a negative sign since the gaps are constructed as logs of the ratio of country productivity vis-à-vis leader productivity) and, depending on the specification:

- GDP growth, as a proxy for the Verdoorn effect (expected to have a positive sign);
- Lagged productivity growth, to control for state dependency (expected to have a positive sign);
- Capacity utilization, to control for business cycle effects (expected to have a positive sign);
- Baumol effect, i.e. the share of service employment in total employment (as services are supposed to show lower productivity growth, we expect a negative sign);
- Growth of labour input, to control for negative productivity effects of hiring larger numbers of low-productivity workers (expected to have a negative sign).

Since our data have the form of an unbalanced panel for 20 OECD countries from about 1960 to about 2004, we can use the Arellano and Bond (1991) method for estimation of a model that includes possibly endogenous but predetermined regressors (such as the lagged dependent variable) in a fixed effects context. In this method, the fixed effects are swept away by first-differencing the equation. Thus, the (first-differenced) regression equation can be written as follows:

$$\Delta\hat{\lambda}_{it} = \beta_1\Delta\hat{w}_{it} + \beta_3\Delta\hat{Y}_{it} + \beta_4\Delta Catchup_{it} + \beta_5\Delta ws_{it} + \beta_6\Delta X_{it} + \Delta\varepsilon_{it} \quad (9)$$

where $\hat{\lambda}$ denotes the growth of labour productivity, $\hat{w}$ is the growth of real wages, $\hat{Y}$ is the growth of GDP, *Catchup* is the log of the ratio between the productivity of a specific country and that of the productivity leader, *ws* denotes the share of wages in national income, and X contains a vector of control variables, including fixed country-effects (which are swept away by first-differencing) and fixed time-effects, and – depending on the precise specification – a lagged dependent variable, a dummy for the unification of Germany, or the share of service sector employment in total employment (see Appendices 1 and 2 for more detail on data and sources). The β*'s* are the coefficients; the subscripts i and t denote panel (country) and time, respectively; and ε denotes the idiosyncratic error term.

It should be noted that there is a potential endogeneity bias relating to two of the independent variables. First, since we explicitly allow for labour productivity growth to cause wage growth, $\hat{w}$ has to be instrumented. Second, as $\hat{Y}$ might be caused by labour productivity growth as well, we instrument this variable too. Apart from this, following Arellano and Bond (1991), we obviously instrument the lagged dependent variable in specifications where it is included.[5]

[5] Figure 1 below shows a general positive trend in wage shares from the 1960s to the 1970s and a general negative trend from the 1970s onwards. One could argue that these trends may render our instrumentation invalid. The trends are, however, partly captured by the time-dummies we have included in the regression. Also, judging from our tests for instrument validity, there is no evidence of a remaining trend in the variables that plagues our instruments.

The extent to which we can use lags of the predetermined variables to construct instruments is limited by the size of our data set. Specifically, we run the risk of obtaining misleading results if the set of instruments becomes too large compared to the number of countries in our panel. This so-called over-fitting bias is shown to be $O(j / N)$, where j denotes the number of instruments and N denotes the number of countries (Arellano, 2003). The suggested limit for the number of instruments is $j = N$ (Arellano and Bond, 1998). However, this limit should be considered more like a rule of thumb than a guarantee that the bias is small. We therefore test the robustness of our estimates by changing the instrument set.

Returning to the over-fitting bias, in our case, with 20 countries and, due to gaps in the data for the 1960s, roughly six waves of five-year periods in the sample, we already reach this boundary when we include just one lag in the list of instruments based on predetermined variables. Indeed, by including only one lag, we have 2*6 instruments based on the predetermined lag of our possibly endogenous variables and about seven exogenous instruments for the additional variables, depending on the specification. We thus obtain an instrument/groups ratio of about 19:20, which is just on the safe side of the boundary. We therefore restrict ourselves to using only one lag of instruments based on predetermined variables, and we test the robustness of our results by varying the instrument set (see Appendix 3).

To generate valid instruments from predetermined lags of the possibly endogenous variables, we include them with a two-period lag. The need to use a lag of two periods, instead of just one, follows from the fact that the error term of the first-differenced equation would still be (possibly) correlated with a one-period lag of a (possibly) endogenous variable. We tested the validity of the instruments by means of the Hansen and Sargan tests as well as the Arellano Bond test for second-order autocorrelation in the residuals. We also tested for higher order autocorrelation in the residuals which was, however, never significant. As can be seen in table 1 below, the validity of the instruments cannot be rejected.

In order to test the robustness of our regression results for the specific instrument list, we performed two tests. First, we switched the instrument list by using the third lag of the predetermined regressors (see Appendix 3). Second, disregarding the over-fitting bias problem, we performed regressions using *all* the available lags as instruments. The former did not substantially alter the coefficients of our regressions, although significance fell somewhat. The latter also kept the coefficients stable, but it increased the significance (not reported).

We calculated standard errors that are robust for country-wise heteroskedasticity and country-specific autocorrelation in the residuals. This estimator is shown to be preferable over the two-step FGLS estimator in the context of our time-series, cross-section data that has asymptotics in T, not in N (Beck, 2001).

Finally, in order to overcome possible drawbacks caused by the five-year averaging of the data, we performed the regressions for all reported specifications five times. We did this by rolling over the five-year averages when selecting the subset of data to be used for estimation. For example, we first pick our sub-sample to run the regression by centring our averages on the years 1960, 1965, …, 2000. Then, we perform a second regression using data that centre on the years 1961, 1966, …, 2001. The third regression rolls over the moving averages centred on the next years; and so on until we have five regressions. This roll-over procedure removes the possibility of obtaining a result that depends on the specific centre years of the averages. The estimates are reported in a way that highlights the robustness of the results obtained from rolling over the moving averages (this will be explained below). The data and descriptive statistics are presented in Appendix 3.

Reported statistics

In order to summarize the regression results for the five rolling estimates, we report the average value of the coefficient, the significance based on the average *p*-value, and the significance based on the average *z*-value. Note that the significance based on the average *z*-value does not necessarily correspond to the significance based on the average *p*-value, because the transformation from *z* to *p* is not linear. Judging significance from average *z*-values would lead us to be overconfident in the significance of coefficients, while taking average *p*-values would lead us to underestimate significance. The following example illustrates this. Suppose that two of our rolling regressions result in pairs of (z, p) values of $(z, p)1 = (0,1)$ and $(z, p)2 = (4, < 0.01)$. This would imply average values of (z, p) of (2,~0.5). Thus, judging significance from the average *z*-value, we would conclude that the average significance is about 5 per cent, while the average *p*-value would imply a significance of only 50 per cent. In other words: a single extreme value in *z* would bias the average value of *z* in a way that would make us overconfident in the results, while a single outlier in *p* would bias the average in a way that would make us under-confident in the results. To facilitate the interpretation of such ambiguous signals, we also report the count of times that a rolling regression yields a coefficient with a *p*-value smaller than a specific significance threshold. We do this for the 10 per cent, 5 per cent and 1 per cent values.

The combination of these statistics allows us to infer not only – from the count – how many times a coefficient reached a certain significance level, but also how robust the significance is. The latter can be interpreted by comparing the significance level based on the average *z*-value with the significance level based on the average *p*-value. If both are close to the value corresponding to the most counted significance level, then the results of the rolling regressions that did not generate coefficients with that particular significance level have near-significant regressors. If the average *z*-values and *p*-values are far away from the value implied by the count (and far away from each other), the results of the rolling regressions that yielded insignificant coefficients are far from significant.

Results

Table 1 summarizes our regression results. First, the Ar2 and the Sargan and Hansen tests indicate that our controls for reversed causality are suitable. This, together with the time lag between dependent and independent variables, supports our interpretation of the regression coefficients as causal effects. Our baseline regression (I) includes wage growth, wage share, catch-up and Verdoorn as explanatory variables. The Verdoorn coefficient is insignificant in our baseline model, so we report a regression without it in model III. In model II, it turns out that the lagged dependent variable (growth of labour productivity lagged by five years) is insignificant. Furthermore, we experiment with controls for the share of services (model IV) and a dummy for the unification of Germany (model V).

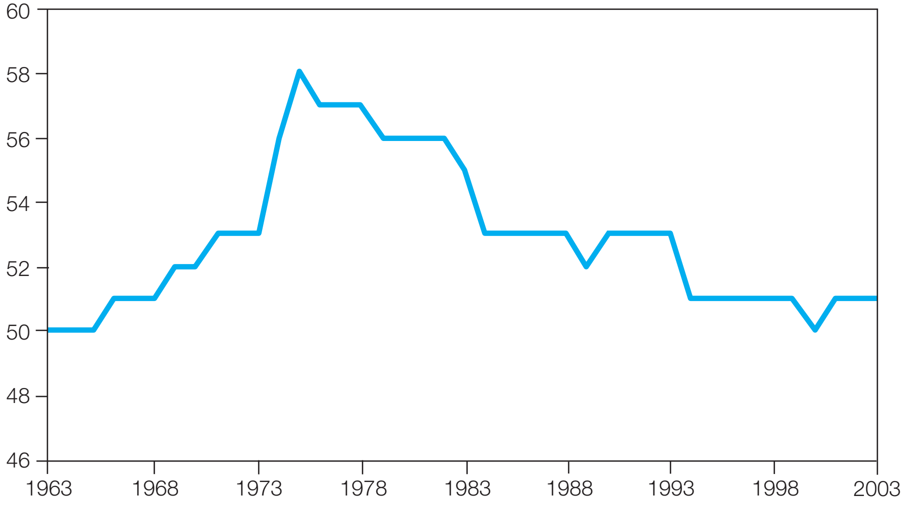
Our baseline regression (I) shows that, with the exception of the Verdoorn coefficient, all variables that explain the growth of labour productivity behave as expected. The tests for the validity of our instruments are not worrying. They indicate that the H0 of valid instruments cannot be rejected, i.e. the Sargan and Hansen tests have an H0 of no correlation between the instruments and the error terms of the regression; the Ar2 test has an H0 of no second order correlation between the errors of the first-differenced regression equation. The validity of the instruments remains stable over all specifications.

Wage growth, in our baseline model, picks up a coefficient of 0.46 with an average significance level of 5 per cent. This implies that a 1 per cent gain in real wages growth translates into additional growth of labour productivity by 0.46 per cent. The coefficient reaches at least a 10 per cent significance level in all five of the rolling regressions, reaching 5 per cent in four of the five regressions. Judging from the similarity between the significance based on the average *p*-value and the significance based on the average *z*-value, there is not much spread in the significance of the individual rolling regressions. Furthermore, the effect of wage growth remains rather stable over the various alternative specifications (II – VI). It has values between 0.35 and 0.46 with an average significance of 10 per cent to 5 per cent (averaging 5 per cent in all but one specification). In all but two of the rolling regressions over the various specifications, wage growth has a significance level of at least 10 per cent.[6]

The wage share in national income is the most significant and robust variable in the regression. It has an average coefficient that ranges from 0.17 to 0.24. This implies that a 1 per cent rise in the wage share in national income accelerates productivity growth by about 0.2 per cent. Considering that the wage shares of national income in the OECD area have fallen by about 7 per cent on average since the 1970s (figure 1), our result implies that labour productivity growth could be boosted by about 1.4 per cent if the wage shares returned to their pre-1970 levels. The coefficient reaches a significance level of

[6] It should be noted that the five-year moving averages drastically reduce the variance of the wage variable, making it less significant than in the previous estimates by Vergeer and Kleinknecht (2011). If included together with the wage share in national income, however, wages are significant.

Figure 1. Average wage share in national income in 20 OECD countries (percentages)



Source: AMECO database.

5 per cent in 23 out of 25 of the rolling regressions for the five specifications. The correspondence between the significance based on average *p*-values and that based on average *z*-values indicates that the significance is quite robust.

The proxy for technological catch-up also performs as expected, although it is not as robust over the specifications as is the wage share. In the various models, it has coefficients between –0.05 and –0.07. This implies that a 10 per cent reduction of the gap between a country's productivity level and the productivity level of the leading country would lower the former's growth rate by roughly 0.6 per cent. In the baseline specification, the coefficient has an average significance level between 10 per cent (based on the average *p*-value) and 5 per cent (based on the average *z*-value). Over the various specifications, its significance ranges from 10 per cent to 1 per cent. Looking at the baseline specification, the difference between the significance implied by the average *z*-value and that implied by the average *p*-value indicates that the insignificant regressors are *far* from being significant. However, the results show considerable robustness over the various specifications. The coefficient does not change much in value and always reaches an average significance level of at least 10 per cent.

The Verdoorn effect turned out insignificant in all our robustness checks. This is not a surprise, considering that we use five-year averaged data in the regressions which strongly reduces the variance of GDP growth. The results confirm our speculation in an earlier paper (using annual data) that the Verdoorn effect may be strongly driven by short-run fluctuations in capacity utilization (Vergeer and Kleinknecht, 2011). As an additional robustness check, we also ran a model that included capacity utilization (not documented here).

Table 1. Results of Arellano-Bond regressions explaining the growth of labour productivity, $\hat{\lambda}$, on five-year averaged values for 20 OECD countries from the 1960s to the 2000s

Independents	(I)	(II)	(III)	(IV)	(V)	(VI)
$\hat{w}$	0.46**/**	0.35*/**	0.44**/**	0.45**/**	0.41**/**	0.41/**
P_1,5,10	1,4,5	1,2,4	1,4,5	2,3,4	0,3,5	1,2,3
ws	0.24***/***	0.17**/**	0.23***/***	0.23***/***	0.22***/***	0.21**/**
P_1,5,10	4,5,5	2,3,4	2,5,5	4,5,5	4,5,5	3,4,5
Catchup	–0.05*/**	–0.06***/***	–0.06**/**	–0.07*/**	–0.05*/**	–0.06**/***
P_1,5,10	1,2,3	4,5,5	1,3,4	2,2,3	1,3,4	2.4.4
Verdoorn $\hat{Y}$	0.16/	0.08/		0.09/	0.21/	
P_1,5,10	0,0,0	0,0,0		0,0,0	0,0,0	
$\hat{\lambda}_{-1}$[a]		–0.11/ (1.37)				
P_1,5,10		0,1,1				
$\hat{l}$						–0.94/
P_1,5,10						0,0,0
Services				–0.03/		
P_1,5,10				0,0,0		
Germany					–0.02/**	
P_1,5,10					2,3,3	
Sargan	$\overline{P}$ = 0.48; $P_{\bar{z}}$ = 0.45	$\overline{P}$ = 0.55; $P_{\bar{z}}$ =0.51	$\overline{P}$ = 0.47; $P_{\bar{z}}$ = 0.45	$\overline{P}$ = 0.68; $P_{\bar{z}}$ = 0.68	$\overline{P}$ = 0.55; $P_{\bar{z}}$ = 0.54	$\overline{P}$ = 0.54; $P_{\bar{z}}$ = 0.53
P_1,5,10	0,0,0	0,0,1	0,0,0	0,0,0	0,0,0	0,0,0
Hansen	$\overline{P}$ = 0.45; $P_{\bar{z}}$ =0.45	$\overline{P}$ = 0.82; $P_{\bar{z}}$ =0.83	$\overline{P}$ = 0.46; $P_{\bar{z}}$ = 0.46	$\overline{P}$ = 0.54; $P_{\bar{z}}$ = 0.54	$\overline{P}$ = 0.42; $P_{\bar{z}}$ = 0.42	$\overline{P}$ = 0.59; $P_{\bar{z}}$ = 0.61
P_1,5,10	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Ar2	$\overline{P}$ = 0.48; $P_{\bar{z}}$ =0.46	$\overline{P}$ = 0.60; $P_{\bar{z}}$ =0.42	$\overline{P}$ = 0.32; $P_{\bar{z}}$ = 0.28	$\overline{P}$ = 0.46; $P_{\bar{z}}$ = 0.42	$\overline{P}$ = 0.43; $P_{\bar{z}}$ = 0.41	$\overline{P}$ = 0.39; $P_{\bar{z}}$ = 0.36
P_1,5,10	0,0,0	0,0,0	0,0,1	0,0,0	0,0,0	0,0,0

Notes: *,** and *** denote average significance of 10, 5 and 1 per cent levels, respectively. Stars on the left side of "/" display the significance based on the average *P*-value. Stars on the right side denote the significance based on the average *z*-value (*t*-distributed). *P*-values are calculated based on standard errors that are robust to general heteroskedasticity and autocorrelation. Numbers indicating P_1,5,10 denote the count of a 1 per cent, 5 per cent, 10 per cent significant result out of the five rolling regressions. $\overline{P}$ denotes the significance level based on the average p-value; $P_{\bar{z}}$ denotes the significance level based on the average *z*-value. All regressions are estimated with a Fixed Effects Arellano Bond procedure that uses available lags to instrument the possibly endogenous regressors ($\hat{w}$ and $\hat{Y}$). Stata routine: Xtabond2 (Roodman, 2009) with options noleveleq small robust. "Services" denotes the share of services; "Germany" denotes a dummy for the unification of Germany. Fixed time effects are included in all the regressions. Sargan and Hansen denote the respective over-identification tests for validity of the instruments. The Sargan-test is not vulnerable for over-fitting, but it is not robust. The Hansen test is robust, but vulnerable for over-fitting. The Ar2 is the Arellano-Bond test for presence of second order autocorrelation in the residuals of the first differenced regression. (a) Instruments of the lagged dependent are based on lag 2 of the dependent. Over-fitting bias is a problem with this regression.

While leaving the results of the other coefficients unchanged, capacity utilization is not significant. This suggests that capacity effects are indeed largely eliminated by using five-year averages. In table 1, the Verdoorn coefficient is rather small and unstable, ranging from 0.08 to 0.21. In none of the specifications is the coefficient significant at any level. If we omit the Verdoorn variable (models III and VI), the other coefficients are hardly affected.

Model II tests for the effect of the lagged dependent variable. It turns out that our model is capable of explaining the growth of labour productivity without including a lagged dependent. As mentioned above, this is not really surprising since the use of five-year averaged values implies a five-year lag of the dependent. This seems to be too long for it still to have an effect on current productivity. It reaches a rather low coefficient which is on average insignificant. It reaches the 5 per cent significance level in only one of the five rolling regressions.

In order to correct for a possible Baumol effect, we run a model with a measure for the share of service industry employment in a country's total employment. Growth of labour productivity may be harder to achieve in services so that a country's labour productivity growth could be influenced by the relative weight of its service sector. As services tend to pay lower wages, this may be an underlying, latent variable that causes low productivity and low wages. In model IV, the share of services does indeed show the expected negative sign, but it fails to show significance and hardly affects the coefficients of the other regressors.

In model V, a dummy for the unification of Germany turns out to be neither very significant nor robust. It reaches a 5 per cent significance level in three of the five rolling regressions. However, its significance based on the average *z*-value (0.04) is much higher than its significance based on the average *p*-value (0.12). This suggests rather unstable significance: in two of the rolling regressions its significance is below 1 per cent, and in one it is between 1 and 5 per cent. In the remaining two rolling regressions, the significance is thus above 26.5 per cent. More importantly, inclusion of this dummy does not affect other coefficients.

Time-dummies (not reported here) turn out to be highly significant over a range of specifications. This is not surprising, as there are some longer recessions during the sample period that are not completely wiped out by the five-year averaging.

Our final model (VI) in table 1 deals with a competing hypothesis for the explanation of our results, namely: the "growth-in-low-productivity-jobs hypothesis", as expressed by the OECD (2003). Indeed, the OECD finds that "a weak trade-off may exist between gains in employment and productivity" and interprets this as arising from newly created jobs at the bottom of the labour market: "For example, decentralisation of wage bargaining and trimming back of high minimum wages may tend to lower wages, at least in the lower ranges of the earnings distribution. Similarly, relaxing employment protection legislation … may encourage expansion of low-productivity/low-pay jobs in services" (ibid., Box 1.4, p. 42). These low-productivity jobs – the OECD's reasoning continues – are created in flexible countries, but not in rigid countries because of unduly high (minimum) wages or high social benefits. In this view, the loss of labour productivity growth through deregulation is mainly a negative by-product of extra jobs created in the low-wage segment. In model VI, we test this hypothesis by including employment growth as a right-hand variable in order to test whether (above-average) employment growth, driven by an influx of low-productivity workers into the labour market, will reduce labour productivity. Jobs growth has the expected negative sign but turns out to be insignificant. In other words, the slow growth of labour productivity must be taking place primarily in *existing* jobs and can hardly be ascribed to the entry of low-productivity workers driven by labour market deregulation.

Discussion and conclusions

It does not come as a surprise that countries with lower *levels* of labour productivity show higher *growth rates* of labour productivity. For example, a country whose labour productivity level is 10 per cent below that of the country with the highest level will achieve annual labour productivity growth that is roughly 0.6 per cent higher. A bit more surprising are our findings with respect to Baumol's law, to which our estimates do not give general support. While Baumol's law may still hold for certain service industries that have low technological opportunities (e.g. care services), other service industries may reap high productivity gains (e.g. IT services). On average, we do not find a significant impact of service sector size on economy-wide labour productivity growth.

Quite a surprising outcome is the insignificance of the Verdoorn law, despite the literature confirming its validity (e.g. McCombie, Pugno and Soro, 2002). In Vergeer and Kleinknecht (2011), we expressed cautious doubts about this law because the inclusion of measures of capacity utilization substantially reduced the Verdoorn coefficients in explaining labour productivity growth. As we had pointed out, however, measures of capacity utilization are far from perfect. In our estimates above, fluctuations in capacity utilization are largely wiped out by the five-year averaging. The outcomes support the impression that much of the evidence in favour of the Verdoorn law seems to have been driven by (insufficient control of) fluctuations in capacity utilization.

The core of this article carries a message to the adherents of the "natural rate of unemployment" or "NAIRU" theory. NAIRU theorists have argued again and again that unemployment is essentially caused by labour market rigidities that prevent the labour market from working as a true "market" in which the price of labour can adjust (downwards) in response to economic shocks. The only way to reduce (the "natural" rate of) unemployment, they conclude, is therefore to remove labour market rigidities.

As cited above, there is abundant evidence in the literature that removing "rigidities" brings down wages. Our estimates show that lower wage growth and lower wage shares in national income both bring down the growth of labour productivity. Actually, this confirms an important claim made by NAIRU theorists: removal of labour market rigidities will lead to increased labour input! Why? At a given rate of GDP growth, lower labour productivity growth implies (by definition) higher growth of labour input – hence a low-productivity, labour-intensive growth path. Ironically, this is reminiscent of the labour-intensive growth that characterized eastern Europe before 1989. In this connection, it should be remembered that lower growth of labour productivity may be particularly undesirable in the near future because of population ageing in many industrialized countries.

Long-run GDP growth hardly differs between the Anglo-Saxon and "Rhineland" countries (Vergeer and Kleinknecht, 2011). Structural reforms that bring about more labour-intensive GDP growth through lower growth of labour productivity may then carry the positive message of creating more jobs. There are, however, doubts as to whether deregulation brings down unemployment rates. Indeed, several studies demonstrate that the empirical underpinnings of this claim lack robustness (Baker et al., 2005; Baccaro and Rei, 2005 and 2007; Howell et al., 2007; Vergeer and Kleinknecht, 2012). We conclude that deregulation results in an increase in hours worked, rather than in a reduction of unemployment rates.

The main consequence of deregulation appears to be that people in the deregulated economies have to work more hours to achieve the same GDP growth rates, which is, by definition, only possible with more modest growth in hourly income. Figure 1 above suggests that, in addition to working more hours for the same growth of national income, labour has sacrificed part of its income share to capital. Economic policy inspired by the "rigidities" view therefore holds costs for workers. But it also hits the unemployed by cutting, for instance, the duration and/or generosity of benefits (Howell et al., 2007). The corollary of the "rigidity" view is the weakening of labour's bargaining position. Besides bringing down the share of labour in national income, this can also favour creation of precarious low-paid jobs. We conclude that if we swallow the bitter supply-side pills and if the "medicine" (Scarpetta, 1996) works, the cost will be a slowing down of labour productivity growth that almost unavoidably has to result in more modest labour incomes and more "working poor" jobs.

Our results also shed light on the discussion about the crisis in the Eurozone. Mainstream economists propose that Mediterranean countries should make the firing of workers easier and cut down on social benefits as part of "structural reforms" of labour markets that will make their economies stronger. Our findings suggest what will happen if this is done: definitely more labour input, but also a weakening of the Mediterranean economies' capacity for innovation and productivity growth. This, in turn, is likely to favour the creation of low-productivity and precarious jobs, rather than skilled jobs.

As evidenced by the above quote from the OECD (2003), even adherents of the NAIRU view cannot avoid noting that deregulation of labour markets might perhaps (somewhat) reduce labour productivity growth. However, they offer an alternative interpretation: a slowdown of labour productivity growth occurred as the removal of rigidities gave labour market access to groups of low-skilled workers with low productivity who were previously excluded from work by rigidities such as high minimum wages or high social benefits. But there are two arguments against this interpretation. First, one can argue that, *ceteris paribus*, the (extra) hiring of low-productivity workers should have increased GDP growth in flexible economies, compared to inflexible economies in which these people do not work. Looking at long-run growth, however, there are hardly indications that such extra growth took place (Vergeer and Kleinknecht, 2011). Second, our model VI (table 1) includes growth of labour input as an explanatory variable. This variable can capture the (extra) hiring of low-productivity workers. It has the expected negative sign, but fails to be significant. This implies that stronger hiring rates do not significantly reduce labour productivity growth, casting doubt on the OECD's explanation.

We conclude that the slowdown of labour productivity growth is hardly caused by bringing low-productivity workers into the labour market, but primarily by lower productivity gains in *existing* jobs. Obvious explanations for the latter have been discussed above, including labour–capital substitution, vintage effects, induced technological change or the malfunctioning of Schumpeterian "creative destruction" as moderate wages protect weaker entrepreneurial talent against being competed away by stronger firms. Moreover, easier hiring and firing will shorten job tenure, thus discouraging training, notably in firm-specific and "tacit" knowledge. Shorter job tenures will also increase various forms of disloyal behaviour such as knowledge leakage or theft, and this will force firms to invest in thicker management bureaucracies for monitoring and control – which in turn is frustrating for creative people. A major disadvantage of higher labour turnover is the weak functioning of the "routinized" innovation model that relies heavily on incremental learning and on path-dependent accumulation of (often "tacit" and firm-specific) knowledge. We conclude that deregulation of labour markets is definitely no free lunch.

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Appendix 1

Description and sources of data

Data for the period 1958–2008 cover the following OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. Series for Germany are for West Germany until 1990; from then onwards they cover united Germany. In the estimation, gaps in the data are filled by zeros. All data are expressed in five-year averages.

$\hat{\lambda}$ = growth of labour productivity per working hour*

$\hat{w}$ = growth of the real wage, calculated as $\Delta \log (ws/\lambda)$

ws = share of wages in national income**

$Catchup_{it} = \log (\lambda_{it}/\lambda_{lt})$ where λ_{it} denotes the labour productivity of a specific country in year t, and λ_{it} denotes the labour productivity of the productivity leader in that same year. Values are taken in the beginning of the five-year period*

$\hat{Y}$ = growth of GDP*

$\hat{l}$ = growth of total hours worked*

Services: Share of services calculated as the number of service sector employees divided by total employment***

Capacity utilization**

Sources: * The Conference Board and Groningen Growth and Development Centre: Total Economy Database, January 2009, available at: http://www.conference-board.org/economics/ [accessed 23 July 2014]; ** Extended Penn World Tables, available at: http://homepage.newschool.edu/~foleyd/epwt/DataDoc3.0.htm [accessed 20 May 2009]; *** Eurostat's AMECO database, version 22 April 2009 [accessed 25 May 2009].

Appendix 2

Descriptive tables of the variables used, by country

Australia

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	40	0.020	0.007	0.001	0.036
$\hat{w}$	36	0.018	0.015	–0.007	0.047
ws	41	0.515	0.030	0.465	0.585
Catchup	45	–0.262	0.032	–0.344	–0.208
$\hat{Y}$	45	0.038	0.009	0.022	0.057
$\hat{l}$	40	0.017	0.007	0.005	0.035
Services	0				

Austria

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	40	0.037	0.017	0.016	0.071
$\hat{w}$	36	0.038	0.022	0.003	0.077
ws	41	0.519	0.025	0.468	0.558
Catchup	45	–0.389	0.246	–0.901	–0.111
$\hat{Y}$	45	0.033	0.013	0.014	0.058
$\hat{l}$	40	–0.006	0.009	–0.021	0.012
Services	29	0.517	0.056	0.432	0.602

Belgium

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	44	0.034	0.018	0.009	0.067
$\hat{w}$	36	0.033	0.027	0.000	0.084
ws	41	0.529	0.033	0.471	0.597
Catchup	45	–0.193	0.217	–0.681	0.000
$\hat{Y}$	45	0.029	0.013	0.007	0.054
$\hat{l}$	44	–0.004	0.009	–0.019	0.016
Services	35	0.559	0.078	0.416	0.673

Canada

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.017	0.009	0.001	0.035
$\hat{w}$	36	0.015	0.013	–0.007	0.041
ws	41	0.542	0.020	0.506	0.573
Catchup	45	–0.185	0.051	–0.319	–0.117
$\hat{Y}$	45	0.036	0.013	0.007	0.061
$\hat{l}$	41	0.019	0.010	–0.004	0.036
Services	35	0.606	0.056	0.506	0.681

Denmark

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	40	0.026	0.011	0.005	0.048
$\hat{w}$	36	0.028	0.016	0.009	0.060
ws	41	0.538	0.020	0.485	0.568
Catchup	45	–0.250	0.130	–0.504	–0.096
$\hat{Y}$	45	0.028	0.012	0.008	0.051
$\hat{l}$	40	–0.001	0.011	–0.022	0.019
Services	39	0.546	0.075	0.397	0.662

Finland

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.035	0.012	0.020	0.066
$\hat{w}$	36	0.034	0.022	–0.001	0.080
ws	41	0.525	0.036	0.472	0.596
Catchup	45	–0.526	0.226	–0.939	–0.268
$\hat{Y}$	45	0.034	0.018	–0.015	0.065
$\hat{l}$	41	–0.003	0.015	–0.045	0.020
Services	45	0.449	0.086	0.300	0.584

France

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.032	0.012	0.017	0.055
$\hat{w}$	29	0.028	0.014	0.007	0.058
ws	35	0.524	0.022	0.464	0.564
Catchup	45	–0.198	0.187	–0.575	–0.006
$\hat{Y}$	45	0.032	0.015	0.011	0.060
$\hat{l}$	41	–0.001	0.008	–0.019	0.013
Services	45	0.507	0.099	0.369	0.667

Germany

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	45	0.031	0.020	–0.011	0.057
$\hat{w}$	16	0.008	0.012	–0.010	0.023
ws	21	0.545	0.015	0.524	0.568
Catchup	45	–0.266	0.154	–0.611	–0.058
$\hat{Y}$	45	0.032	0.016	0.010	0.066
$\hat{l}$	45	0.000	0.021	–0.021	0.061
Services	45	0.431	0.093	0.302	0.596

(continued overleaf)

Ireland

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	44	0.041	0.012	0.009	0.062
$\hat{w}$	36	0.035	0.025	–0.007	0.078
ws	41	0.499	0.057	0.387	0.597
Catchup	45	–0.623	0.285	–1.118	–0.244
$\hat{Y}$	45	0.046	0.019	0.012	0.091
$\hat{l}$	44	0.007	0.019	–0.019	0.041
Services	34	0.461	0.066	0.356	0.576

Italy

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.034	0.023	0.004	0.081
$\hat{w}$	36	0.027	0.031	–0.011	0.088
ws	41	0.463	0.046	0.392	0.567
Catchup	45	–0.273	0.223	–0.882	–0.069
$\hat{Y}$	45	0.033	0.017	0.011	0.068
$\hat{l}$	41	–0.004	0.011	–0.027	0.011
Services	45	0.414	0.094	0.272	0.555

Japan

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.042	0.025	0.015	0.094
$\hat{w}$	36	0.044	0.030	0.005	0.102
ws	41	0.519	0.049	0.425	0.572
Catchup	45	–0.641	0.302	–1.388	–0.365
$\hat{Y}$	45	0.050	0.033	0.002	0.109
$\hat{l}$	41	0.004	0.009	–0.014	0.019
Services	35	0.463	0.060	0.359	0.576

Netherlands

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	45	0.027	0.016	–0.006	0.053
$\hat{w}$	32	0.019	0.022	–0.021	0.063
ws	37	0.541	0.031	0.493	0.601
Catchup	45	–0.150	0.119	–0.415	–0.031
$\hat{Y}$	45	0.033	0.013	0.007	0.055
$\hat{l}$	45	0.006	0.009	–0.014	0.022
Services	36	0.595	0.073	0.461	0.708

New Zeland

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	44	0.015	0.010	–0.012	0.031
$\hat{w}$	36	0.008	0.012	–0.011	0.033
ws	41	0.490	0.049	0.415	0.568
Catchup	45	–0.459	0.067	–0.601	–0.351
$\hat{Y}$	45	0.027	0.014	–0.003	0.051
$\hat{l}$	44	0.011	0.011	–0.018	0.032
Services	16	0.631	0.027	0.582	0.667

Norway

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	44	0.035	0.010	0.019	0.053
$\hat{w}$	32	0.027	0.021	–0.009	0.068
ws	37	0.515	0.041	0.436	0.590
Catchup	45	–0.214	0.212	–0.608	0.000
$\hat{Y}$	45	0.036	0.009	0.016	0.048
$\hat{l}$	44	0.001	0.007	–0.012	0.018
Services	39	0.593	0.076	0.450	0.689

Portugal

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	44	0.036	0.022	0.007	0.078
$\hat{w}$	34	0.034	0.032	–0.014	0.089
ws	39	0.475	0.045	0.410	0.596
Catchup	45	–0.907	0.206	–1.431	–0.714
$\hat{Y}$	45	0.041	0.018	0.009	0.071
$\hat{l}$	44	0.005	0.011	–0.012	0.041
Services	28	0.386	0.063	0.294	0.488

Spain

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	40	0.039	0.024	–0.007	0.086
$\hat{w}$	36	0.037	0.026	0.000	0.086
ws	41	0.489	0.031	0.440	0.551
Catchup	45	–0.622	0.330	–1.370	–0.281
$\hat{Y}$	45	0.045	0.022	0.015	0.097
$\hat{l}$	40	0.005	0.023	–0.035	0.050
Services	25	0.501	0.047	0.401	0.558

(continued overleaf)

Sweden

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.025	0.014	0.008	0.053
$\hat{w}$	36	0.020	0.019	–0.010	0.053
ws	41	0.597	0.033	0.530	0.666
Catchup	45	–0.265	0.078	–0.479	–0.178
$\hat{Y}$	45	0.026	0.013	–0.001	0.053
$\hat{l}$	41	0.001	0.007	–0.013	0.014
Services	35	0.549	0.063	0.425	0.640

Switzerland

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	40	0.017	0.012	0.000	0.037
$\hat{w}$	36	0.020	0.013	0.003	0.047
ws	41	0.589	0.030	0.535	0.636
Catchup	45	–0.193	0.075	–0.372	–0.082
$\hat{Y}$	45	0.023	0.017	–0.009	0.060
$\hat{l}$	40	0.003	0.011	–0.023	0.022
Services	14	0.585	0.024	0.543	0.626

United Kingdom

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	41	0.028	0.007	0.013	0.042
$\hat{w}$	36	0.025	0.011	0.006	0.049
ws	41	0.576	0.029	0.530	0.652
Catchup	45	–0.349	0.129	–0.571	–0.213
$\hat{Y}$	45	0.025	0.009	0.007	0.040
$\hat{l}$	41	–0.003	0.011	–0.020	0.019
Services	26	0.616	0.067	0.487	0.724

United States

Variable	Obs.	Mean	Std. dev.	Min.	Max.
$\hat{\lambda}$	45	0.019	0.006	0.008	0.031
$\hat{w}$	36	0.017	0.010	–0.004	0.037
ws	41	0.596	0.016	0.566	0.622
Catchup	45	–0.017	0.030	–0.081	0.000
$\hat{Y}$	45	0.033	0.009	0.016	0.056
$\hat{l}$	45	0.014	0.008	–0.002	0.028
Services	45	0.568	0.069	0.464	0.689

Appendix 3

Results of Arellano-Bond regressions explaining the growth of labour productivity ($\hat{\lambda}$), on five-year averaged values for 20 OECD countries from the 1960s to the 2000s, using instruments based on the third lag of potentially endogenous regressors

Independents	(I)	(II)	(III)	(IV)	(V)	(VI)
$\hat{w}$	0.42*/*	0.38/*	0.44*/**	0.36*/**	0.40*/*	0.58***/***
P_1,5,10	0,2,3	0,2,4	1,3,4	1,3,3	0,1,4	2,5,5
ws	0.22**/**	0.18/*	0.22*/***	0.19**/***	0.21**/**	0.27***/***
P_1,5,10	2,4,4	0,2,3	3,4,4	4,4,4	1,4,4	4,5,5
Catchup	–0.05**/**	–0.05**/***	–0.06**/**	–0.07**/***	–0.05**/**	–0.05**/**
P_1,5,10	2,4,5	1,4,5	1,5,5	1,5,5	1,4,5	1,3,4
Verdoorn $\hat{Y}$	0.23/	–0.15/		0.16/	0.24/	
P_1,5,10	0,0,1	0,0,1		1,1,1	0,0,1	
$\hat{\lambda}_{-1}$[a]		–0.15/				
P_1,5,10		0,0,1				
$\hat{l}$						–0.05/
P_1,5,10						0,0,1
Services				–0.05/		
P_1,5,10				0,0,0		
Germany					–0.02/*	
P_1,5,10					1,2,3	
Sargan	$\overline{P}$ = 0.53; $P_{\overline{z}}$ = 0.53	$\overline{P}$ = 0.49; $P_{\overline{z}}$ =0.44	$\overline{P}$ = 0.34; $P_{\overline{z}}$ = 0.32	$\overline{P}$ = 0.45; $P_{\overline{z}}$ = 0.38	$\overline{P}$ = 0.50; $P_{\overline{z}}$ = 0.51	$\overline{P}$ = 0.43; $P_{\overline{z}}$ = 0.33
P_1,5,10	0,0,0	0,0,1	0,0,0	0,0,1	0,0,0	1,1,0
Hansen	$\overline{P}$ = 0.40; $P_{\overline{z}}$ =0.37	$\overline{P}$ = 0.81; $P_{\overline{z}}$ =0.82	$\overline{P}$ = 0.28; $P_{\overline{z}}$ = 0.25	$\overline{P}$ = 0.45; $P_{\overline{z}}$ = 0.4	$\overline{P}$ = 0.50; $P_{\overline{z}}$ = 0.49	$\overline{P}$ = 0.43; $P_{\overline{z}}$ = 0.39
P_1,5,10	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,0
Ar2	$\overline{P}$ = 0.49; $P_{\overline{z}}$ =0.46	$\overline{P}$ = 0.60; $P_{\overline{z}}$ =0.52	$\overline{P}$ = 0.27; $P_{\overline{z}}$ = 0.25	$\overline{P}$ = 0.31; $P_{\overline{z}}$ = 0.22	$\overline{P}$ = 0.46; $P_{\overline{z}}$ = 0.43	$\overline{P}$ = 0.42; $P_{\overline{z}}$ = 0.39
P_1,5,10	0,0,0	0,0,0	0,0,1	0,0,1	0,0,0	0,0,0

Notes: *,** and *** denote average significance of 10, 5 and 1 per cent levels, respectively. Stars on the left side of "/" display the significance based on the average *P*-value. Stars on the right side denote the significance based on the average *z*-value (*t*-distributed). *P*-values are calculated based on standard errors that are robust to general heteroskedasticity and autocorrelation. Numbers indicating P_1,5,10 denote the count of a 1 per cent, 5 per cent, 10 per cent significant result out of the five rolling regressions. $\overline{P}$ denotes the significance level based on the average *p*-value; $P_{\overline{z}}$ denotes the significance level based on the average *z*-value. All regressions are estimated with a Fixed Effects Arellano Bond procedure that uses available lags to instrument the possibly endogenous regressors ($\hat{w}$ and $\hat{Y}$). Stata routine: Xtabond2 (Roodman, 2009) with options noleveleq small robust. "Services" denotes the share of services; "Germany" denotes a dummy for the unification of Germany. Fixed time effects are included in all the regressions. Sargan and Hansen denote the respective over-identification tests for validity of the instruments. The Sargan test is not vulnerable for over-fitting, but it is not robust. The Hansen test is robust, but vulnerable for over-fitting. The Ar2 is the Arellano-Bond test for presence of second order autocorrelation in the residuals of the first-differenced regression. (a) Instruments of the lagged dependent are based on lag 2 of the dependent. Over-fitting bias is a problem with this regression.