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The productivity effects of labor market deregulation: evidence from German firms during 2010–2019

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In the early 2000s, the German government introduced the Hartz reforms, which deregulated German labor markets. These reforms were praised internationally as striking a balance between job growth and productivity growth. While macroeconomic research has shown that the reforms have indeed lowered German unemployment, their effects on labor productivity need to be better understood. This paper addresses the impact of temporary agency work (TAW) on German labor productivity during 2010–2019, based on data from a firm-level panel of the German Institute for Employment Research (IAB). It contributes to the rising number of firm-level studies by extending their results in a broader temporal perspective, during which TAW intensities have increased substantially, especially in TAW-using firms. The system generalized method of moment (GMM) estimations based on a firm-level data set with 13,197 observations for the period 2010–2019 show that a robust hump-shaped relationship exists between the extent of TAW and the firms' labor productivity. We find that the increase in the use of TAWs following the Hartz reforms has, on average, positively contributed to labor productivity growth in German firms. However, the findings also show that if numerical flexibility is increased too much, productivity growth in Germany will suffer. This is particularly the case for several industrial sectors that are important in the German economy. These results are important given recent calls for more labor market flexibility to help firms grow in an increasingly turbulent global economy.

JEL classification: J24, J21 J50, D22, D24

1. Introduction

A central question in the debate on "the future of work" in Europe is how robotization, artificial intelligence, and digital work platforms will affect future European employment, wages, and working conditions in an increasingly competitive global economy. The COVID-19 health crisis has further accelerated digitization and encouraged a wave of experimentation with novel modes of business and work based on these new technologies Organisation for Economic Co-operation and Development (OECD, 2021). Fearing that these new technologies will lead to a net destruction of jobs, at least initially and during a prolonged period of transition, European policymakers prioritize creating jobs over job security and working conditions (Servoz, 2019). To create more jobs, it is held that European labor markets have to be further reformed to allow firms' "flexibility" in adjusting their workforces to the market disruption originating from the new technologies (Eichhorst *et al.*, 2017). However, it is also well understood that maintaining high labor productivity is a necessary condition for maintaining high wages and good working conditions. That means that when labor markets are made more "flexible," to create new jobs, this has to be done in ways that do not hurt firm-specific knowledge embodied by workers

and labor productivity (OECD, 2021). "Steering growth in a more resilient and inclusive direction requires swift reallocation of resources. This means removing policy barriers where they exist, for firms to become more dynamic, innovative, and greener, thereby facilitating the reallocation of resources, both within and between firms Failure to reduce reallocation frictions can also reduce job opportunities, stifle innovation, limiting productive career prospects and technology adoption, thus hampering productivity growth," writes the OECD (2021: 19) in the *Going for Growth Report 2021*. And in particular, "[i]ncreasing the flexibility of labour markets aids productivity-enhancing resource reallocation" (OECD, 2021: 23).

It is in this context that Germany's labor market reforms of the early 2000s, the so-called Hartz reforms (Kirkegaard, 2014; Odendahl, 2017), are widely held up as providing an example to other European economies of reforms, which, by successfully removing policy barriers and reducing reallocation frictions, managed to balance "job growth" (through labor market "flexibilization") and "productivity growth." As part of this policy scheme, the use of temporary agency work (TAW) was facilitated. Germany's government announced the Hartz reforms as part of broader efforts to make Germany better prepared for the upcoming decade (Odendahl, 2017). At the time, the unemployment rate of Germany was 11%, almost 1 in 20 workers was unemployed for more than a year, and Germany's economic growth had ground to a halt. The Economist (1999) scoffed at Germany's rigid economic model, calling it "the sick man of Europe" compared to faster-growing Anglo-Saxon economies. However, after 2005 (following the reforms), Germany evolved into "*Powerhouse Deutschland*" (O'Sullivan, 2010; Dustmann *et al.*, 2014), arguably the most powerful economy of today's Europe. The German economy managed to recover relatively quickly and strongly from the Global Financial Crisis of 2008 (Kirkegaard, 2014; Storm and Naastepad, 2015), mostly due to its exceptionally strong manufacturing export performance. Germany's unemployment rate came down from 11.2% in 2005 to 5% in 2014 and remained around 4% during 2015–2020. Following the dominant narrative, the drastic labor market deregulation of the Hartz reforms made Germany's export-oriented manufacturing sector more cost-competitive (Dadush, 2010; Ma and McCauley, 2014). As a result, Germany's labor market reforms are held up as a successful example to be followed by other EU nations (Kirkegaard, 2014).

The dominant narrative has been challenged by research (Storm and Naastepad, 2015; Odendahl, 2017) that shows that the Hartz reforms did have no measurable impacts on German real wage growth (which was restrained well before 2004, due to high unemployment and the threat of outsourcing and offshoring to Eastern Europe) or on Germany's manufacturing export growth (which benefitted from rising world demand). But the Hartz reforms contributed to lower unemployment (Krebs and Scheffel, 2013; Hochmuth *et al.*, 2021), as they led to a shortening of the time needed for job searching and matching between firms and workers and also because they contributed to a large low-wage sector (Odendahl, 2017).

It needs to be clarified, however, what the effect has been of the flexibility measures introduced as part of the Hartz reforms on labor productivity. Most macroeconomic analyses conclude that Germany's flexible labor markets did little, if anything, to boost labor productivity (Storm and Naastepad, 2015; Odendahl, 2017). However, as these studies are based on evaluating macroeconomic or industry-level data, their findings must be read as average impacts, which may hide or obscure relevant effects at the firm level. Although there is a rising number of microeconomic (firm-level) studies on the impact of Germany's labor market flexibilization on labor productivity (Beckmann and Kuhn, 2009; Hirsch and Mueller, 2012; Nielen and Schiersch, 2016; Pfeifer and Weche, 2020), these studies analyze data around or just after the Hartz reform.

This paper addresses the impact of TAW on German labor productivity during 2010–2019, based on data from a firm-level panel of the German Institute for Employment Research (IAB). The paper makes three contributions to the literature. Firstly, we extend the analyses in broader temporal perspective, analyzing firm panel data for the period 2010–2019, in which TAW intensities have increased substantially compared to before 2010, especially in TAW-using firms The data show a bifurcation of German firms into a majority of firms that are not using temporary agency workers (TAWs) and a small minority reporting a heavy TAW use. Hence, while average TAW intensities remain low, it may no longer hold that most TAW-using firms do

so in a productivity-enhancing manner, warranting a reconsideration of the question. During 1991–2019, and particularly following the Hartz reforms of 2003–2005, the number of TAWs rose at a spectacular compound annual growth rate of almost 7%, while the total number of employed persons grew at only 0.44% per year (Bundesagentur für Arbeit, 2015, 2017).[1]

Secondly, unlike most earlier studies, we locate our *firm-based* findings, which are consistent with earlier studies, within the larger literature on Germany's changing industrial relations system (Baccaro and Benassi, 2017; Herrero, 2021). Until now, Germany's (two-tier) industrial relations system has been an important source of the country's competitive advantage, and we argue that the increased use of TAWs could be a harbinger of a more structural flexibilization of labor relations in Germany's manufacturing core. Such an assessment of the productivity impacts of flexible labor has become only more important in the context of a chronic weakening of the German economy since 2022 (Bofinger, 2024). Finally, our analysis complements other recent studies that consider the impact of labor market flexibility on innovation, the cumulativeness of knowledge, and R&D in Germany and other countries (e.g., Hoxha and Kleinknecht, 2020, 2024). Our findings reinforce complementary findings that high labor flexibility is negatively related to the probability of investing in R&D and/or introducing innovations.

We relate TAW to labor productivity growth to test for a possible effect of the prevalence of "flexible, temporary" work on labor productivity. Just like Hirsch and Mueller (2012), we find that the use of TAWs has two opposing effects on productivity: on the one hand, the increased use of TAWs raises productivity by lowering costs and increasing numerical flexibility for employers. On the other hand, TAWs harm productivity as they arguably possess less firm-specific knowledge, and the work spirit of permanent workers suffers from TAW use. The net impact of TAW use on productivity is theoretically ambiguous, therefore. We measure labor productivity at the level of all engaged persons in the firm. Hence, concerns that TAW increases productivity by adding persons off-record do not apply.

We find a hump-shaped relationship between TAW intensity and labor productivity growth. The effects on productivity growth are positive for low and medium TAW intensities, up until the turning point is reached at a TAW intensity of around 10.5%. For higher TAW intensities, the productivity growth benefits diminish and eventually turn negative. The findings underscore the positive impacts of the numerical flexibility provided by TAW on the productivity performance of the large majority of Germany's firms but simultaneously signal that too much flexibility does harm labor productivity growth. That happens to be the case in around one-third of TAW-using firms in our panel dataset, many of which are part of Germany's manufacturing core (see Table 7).

The paper is structured as follows: In the next (second) section, we discuss the industrial relations system of Germany as the context against which the Hartz reforms were implemented. Starting from its characterization in the varieties of capitalism literature, we show that the German industrial system, in its typical form, was composed of a high-productivity (manufacturing) core and a lower-productivity periphery that provided services and added flexibility to the system. We argue that maintaining high labor productivity in the (manufacturing) core is crucial to maintaining high standards in wages and working conditions.

We then discuss the rise of atypical employment in Germany and present some descriptive analyses regarding its development. We show that, although small in relative terms, TAW has undergone tremendous growth and can be seen as indicative of the direction of transformation of Germany's employment relations (Herrero, 2021). The section concludes with an overview of regulatory changes regarding TAW. In the third section, we discuss econometric work regarding TAW and other forms of external flexibility. We then describe the data and present the methodology that is used for the empirical estimations. In section 5, we present the findings. In the concluding section, we compare the findings to prior work and discuss limitations and opportunities for future research.

[1] We define temporary agency work as engaging workers of a different company to undertake tasks at the host company. Put differently, a TAW works at the host company without being on the host company's payroll.

2. Background

2.1. Industrial relations in Germany

In recent times, Germany's industrial relations system (*Modell Deutschland*) has changed. Originally, *Modell Deutschland* stood for high levels of standard (permanent) employment, good working conditions, centralized (sectoral) collective bargaining, and relatively strong employees' representation in work councils[2] in the productive export-oriented manufacturing sector (Thelen, 2014; Herrero, 2021). This manufacturing "core" featured long-lasting labor relations (long average tenures) with a focus on the steady accumulation of firm-specific skills and incremental innovation. Investment by workers in firm-specific skills was promoted and protected by relatively long notice periods and dismissal protection (Hall and Soskice, 2001). Employees did not find themselves in constant threat of dismissal, and as a result, they were less concerned with their general employability and more willing to invest in cumulative (often tacit) firm-specific skills and knowledge (Baccaro and Benassi, 2017; Kleinknecht, 2020). German firms could afford to invest in training as the institutional context encouraged the retainment of workers. Collective bargaining equalized working conditions across firms and made job-hopping and headhunting less attractive, also contributing to long tenure.

The entry into corporate employment is the apprenticeship system, and the continuous investment into their skill enabled shop-floor workers to climb the career ladder into managerial positions within their field of expertise. These long-lasting labor relations went hand in hand with the availability of "patient long-term capital" held by long-term strategic shareholders which often include the family owners and the "Hausbank" (Hall and Soskice, 2001: 22). Patient shareholders enabled firms to pursue investments that return profits only in the long run, so managers were less pressured by short-term profitability. But it also allowed firms to maintain their highly skilled labor force when demand falls short of expectations. Germany's manufacturing core employs approximately one-third of the workforce in large manufacturing establishments, business services, and construction (Herrero, 2021).

Importantly, this coordinated core of Germany's economy was complemented by a periphery of low-productivity services, characterized by a high incidence of "flexible" non-standard employment (Storm and Naastepad, 2015; Baccaro and Benassi, 2017). The low-wage periphery provided the needed economic flexibility (to the manufacturing core) while at the same time protecting the real wages of the core-sector workers (Hassel, 2014). This periphery (which employs approximately two-thirds of Germany's labor force) is formed by small and medium enterprises (SMEs) in non-advanced manufacturing and business and by all establishments in consumer and personal services (Herrero, 2021: 23). Germany is thus characterized by a comparative "rigidity" in its labor relations in the core, which is offset by flexibility in the periphery.

However, in response to the high unemployment following German unification in 1990, increased globalization (leading to outsourcing and offshoring), and the introduction of the euro in 2002, Germany's system of industrial relations was deregulated, and non-standard employment expanded, also in the manufacturing core. Sectoral bargaining coverage declined, wage bargaining was slowly decentralized (to the level of firms), and the share of employees covered by a work council declined from 50% in 1996 to 43% in 2018.[3] Labor market deregulation began in 1985 with the approval of the Employment Promotion Act (*Beschäftigungsförderungsgesetz*), which extended the maximum duration of fixed-term contracts (until 18 months) and

[2] In Germany's system of codetermination, workers are entitled to form works councils in firms with more than five employees (Tüselmann and Heise, 2000; Addison, 2009). Work councils have a right to participate in management decisions such as "information rights (mainly in business and strategic matters), consultation rights (mainly in personnel matters) and co-determination rights (mainly in social matters)." In case of disagreement, works councils must rely on labor courts. Therefore, firm management cannot unilaterally decide on topics such as pay structures or working hours, occupational health, or closure of business units. The work council must be informed beforehand if a firm wishes to dismiss an employee (Tüselmann and Heise, 2000). Without having informed the works council, dismissal would not be legally defensible. The extent of codetermination depends on the size of the enterprise (Bundesministerium für Arbeit und Soziales, 2017). Companies with more than 2000 employees (including daughter companies, except for steel and mining industries) must compose their supervisory board of equal shares of employee representatives and shareholder representatives. In publicly traded companies with 501 to 2000 employees, the supervisory board must consist of one-third employee representatives.

[3] See: https://www.nomos-elibrary.de/10.5771/0342-300X-2019-4-290.pdf?download_full_pdf=1

TAW (from 3 to 6 months). This Act was followed by further deregulation of rules concerning part-time employment (in 2001), fixed-term employment (in 1997), and temporary agencies (in 1997 and 2002) (Herrero, 2021). The Hartz reforms of 2003–2005, finally, fully liberalized agency work, abolishing the maximum length of temporary work. The Hartz I reform abolished the principle of "equal pay for equal work," and the Hartz II reform deregulated marginal employment, allowing the creation of low-wage mini-jobs with limited social security contributions and no cap on the maximum working-time limit. The Hartz III reforms mainly reinforced the government's active labor market policies. Finally, aiming to reduce the workers' reservation wage, the Hartz IV reforms reduced the duration of unemployment benefits to a maximum of 18 months and introduced means-tested social assistance for the long-term unemployed (Herrero, 2021).

The impacts of the Hartz reforms have generated much debate in Germany and beyond (Odendahl, 2017). Most model analyses and (micro-)econometric studies find that the Hartz reforms helped to lower (non-cyclical) German unemployment, but the quantitative findings vary considerably. The estimated decline in the German unemployment rate during 2005–2015, caused by the Hartz laws, falls in the range 1 and 3 percentage points (Krebs and Scheffel, 2013; Hochmuth *et al*., 2021). However, recent findings of Bradley and Kügler (2019) suggest that the Hartz reforms did not reduce Germany's unemployment as a whole, but only shortened the average duration of unemployment. The Hartz reforms did lead to a fall in the wages of low-skilled workers (Dustmann *et al*., 2014; Bradley and Kügler, 2019; Herrero, 2021) and also contributed to increasing wage dispersion and an increase in income inequality (Odendahl, 2017; Spannagel and Molitor, 2019; Immel, 2021). Underlying the decline in unemployment, the fall in wages and the rise in inequality is a considerable increase in non-standard forms of employment over time (see Figure 1)—both in Germany's manufacturing core and its (services) periphery. The rise in non-standard employment is a manifestation of the transformation of the German industrial relations system (Herrero, 2021), which has been a critical factor underlying the high productivity growth and strong international competitiveness of German businesses. Maintaining high labor productivity in the manufacturing core is a necessary condition for maintaining high wages and good working conditions. It is, therefore, remarkable that the impact of the growth of atypical employment in general, and TAWs in particular, on the growth on business productivity, has so far received relatively little microeconomic empirical attention (for exceptions, see Hirsch and Mueller, 2012; Pfeifer and Weche, 2020).

2.2. The rise of atypical employment including agency work

Atypical forms of employment include (i) part-time work (*Teilzeitarbeit*), which is characterized by less regular weekly working hours than collective agreements defined for standard employment (about 35 to 40 hours); pay is proportionally reduced; (ii) fixed-term employment (*befristete Beschäftigung*) which means that the contract ends automatically after an indicated period; existing legal provisions of dismissal protection do not apply; (iii) marginal employment (*geringfügige Beschäftigung*) which represents the "mini-jobs" enabled by the Hartz reforms; monthly earnings from these "mini-jobs" have to remain below the threshold of €538; and (iv) agency work (*Leih- or Zeitarbeit, Arbeitnehmerüberlassung*), or TAW, which differs from all other forms because of its tripartite relationship between the employee, the work agency, and the company hiring the employee; if companies make use of this form, they have to pay the agency an extra premium on top of the (comparatively low) wage employees are paid (Keller and Seifert, 2012).

The incidence of all four forms of atypical employment has grown over time as illustrated in Figure 1. The share of non-standard employment in total employment increased from 16.9% in 1991 to 36.5% in 2007; it then declined to 27.5% in 2022. Part of this decline can be attributed to regulatory changes reducing the maximum duration of temporary work and pay equality compared to regular employees (see also Table 1). But also, market-related developments played a role. The employment upswing as of 2005 likely reduced the necessity to take up atypical employment (Sperber and Walwei, 2015). The employment upswing was accompanied by a policy of wage moderation, further fuelling the upward employment trend and reducing the relative size of atypical employment.

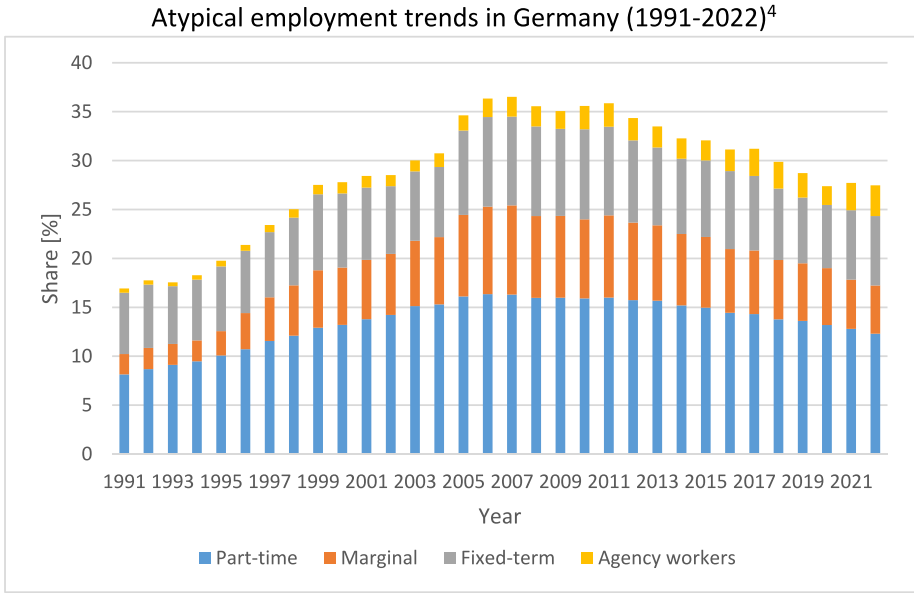

Figure 1. Atypical employment trends in Germany (1991–2022)[4]

Table 1. Regulatory changes pertaining to temporary agency work in Germany

Date	Regulatory change
1985	- Prolongation of the maximum duration from 3 to 6 months
1994	- Maximum duration increases to 9 months Repeal of the synchronization ban for from the Federal Employment Agency (FEA) assigned and difficult to place unemployed people
1997	- Increase of the maximum duration to 12 months Permission to synchronize the first use with the employment contract for fist-time secondment Permission to unique time limitation without objective reason and repeated time limitations of contracts with the same TAW
2002	-Increase of the maximum duration to 24 months, enforced conformity after 12 months
2003	- Discontinuation of synchronization and rehiring ban and the maximum duration Enforced conformity principle in absence of divergent collective agreements
2009	- "Law on securing employment and stability" enables short time work for secondment workers (till December 31, 2011)
April 30, 2011	- Introduction of the "revolving door clause"[a] Introduction of a lower wage limit
December 1, 2011	- Implementation of the EU-temporary agency work regulation (creation of the application area of the temporary agency work jurisdiction, among others)
2012	- Introduction of a lower wage limit till October 31, 2013, as of April 1, 2014: Second act regarding the lower wage limit (till December 31, 2016)
April 1, 2017	-After 9 months, TAWs must receive the same pay as permanent staff Maximum duration reduced to 18 months

Sourced and modified from Bundesagentur für Arbeit (2018a). Dates: January 1, if not specified otherwise.
[a]Prohibits the dismissal of employees and re-engaging them as TAWs under worse contractual conditions within 6 months. TAW, temporary agency work.

Part-time employment is the most widespread form of atypical employment in Germany. In Figure 1, we list the share in total paid employment of part-time employees who work fewer than 20 hours per week. This share doubled from 8.1% in 1991 to 16.3% in 2006 and 2007, after which it declined to 12.3% in 2022. We must note here that the share in total employment of all part-time workers (including part-timers working more than 20 hours per week) is higher and increased from 13.7% in 1991 to 26.3% in 2022. Its long-term, more or less steady increase, independent of the stage of the business cycle, is closely related to the growing participation of women in the labor force; women account for more than 80% of all part-time employees.

The proportion of workers on fixed-term contracts in total paid employment was 6.3% in 1991 and peaked at 9.2% in 2008 and 2010, but then declined to 7.1% in 2022. Fixed-term employment grew in personal and consumer services as well as in large business service establishments (Herrero, 2021). Marginal employment (the "*mini jobs*"), which accounted for 2.1% of all jobs in 1991, rose quite considerably to 9.1% of total employment in 2007; in 2022, it accounted for 4.9% of total employment. Mini-jobs are particularly important for SMEs in services and non-advanced manufacturing (Herrero, 2021).

Finally, agency work continues to account for only a relatively small segment of the labor market and, in purely quantitative terms, constitutes the least important atypical form. From a comparative perspective, its share is relatively low. However, the share of agency workers in total employment has increased from 0.4% in 1991 to 1.1% in 2003, and then following the Hartz deregulation, more than doubling to 2.7% in 2018 and 3.2% in 2022. Its unusually high growth rate (of 7% per annum during 1991–2022) has triggered a disproportionate level of public interest in this type of non-standard work (see Herrero, 2021). The increased use of TAWs adds strategic flexibility to employers where it was absent earlier. Technically speaking, TAWs are not employees as they are not on the company's payroll. Hence, firms can use TAWs strategically to optimize their number of employees to stay below thresholds in codetermination law. But it also offers a way around the influence of work councils as TAWs are, for instance, not covered by collective agreements.

Agency work is largely found in Germany's manufacturing core, although it also became more prevalent in the service sectors (Herrero, 2021). The majority of agency workers (71%) are male and they work mainly in the metal-working and electrical industry, but also as casual employees in other manufacturing industries (Keller and Seifert, 2012). The growth of the share of agency work in total employment is very strongly correlated[5] with the growth in the share of atypical employment in total employment in Germany during 1991–2019—the growth of TAW, therefore, is an indicator of a larger process of transformation of standard employment into non-standard employment. Because the introduction of TAWs into the system of industrial relations of Germany's manufacturing core threatens to undermine many of its defining features, it has come with extensive regulation on the use of TAWs.

2.3. The regulation of TAW in Germany

Since 1972, TAW is regulated in Germany (Bundesagentur für Arbeit, 2018a). Over time, the initial law has been modified several times, most recently in April 2017. Table 1 summarizes the most important regulatory changes regarding temporary work or "secondment." Many of the regulatory changes address the maximum duration of TAW, which refers to the time span a TAW is allowed to work at the host firm. The boldest change occurred in 2002 when the maximum duration increased from 12 to 24 months; interestingly, the maximum duration of TAW was reduced to 18 months in April 2017 (Table 1). Among the remaining reforms, various deal with TAW as a substitute for regular employment or a tool to economize wage costs. For example, in April 2011, the revolving door clause was introduced, forbidding that a regular employee could be dismissed and re-engaged via a temporary work agency, or in April 2017, the same pay was introduced and stipulated that TAWs must receive the same pay as regular employees after 9 months.

[5] The estimated (OLS) coefficient of the TAW share (in total employment) on the share of atypical employment (in total employment) is 6.49 (t-value = 7.29); the $R^2 = 0.66$.

3. Flexible labor and firm productivity

The microeconomics of employment relations is (explicitly or implicitly) oriented toward regular (standard) jobs and mostly overlooks atypical (non-standard) employment. Nevertheless, businesses may have sound reasons to use TAWs. Previous (management) research on temporary work identifies two such motivations for using atypical employment contracts. Firstly, the use of TAWs (and other flexible work arrangements) offers firms greater external (numerical) flexibility than what is achievable based on regular employment alone (which comes with costs to terminate job contracts). External flexibility is especially important to Germany's (export-oriented) manufacturing firms, which must respond to demand fluctuations (Nielen and Schiersch, 2016). It provides these firms with room to handle variability in demand, to buffer their regular workforce during downturns, thus allowing them to sustain internal labor markets, and to carry on production when regular workers are temporarily absent. Hence, to the extent that TAW contracts allow firms to work with a stable core of permanent workers, which TAWs supplement in high-growth periods, temporary workers enable the development of firm-specific human capital and the tacit knowledge of the core workers. Thus, TAWs indirectly contribute to higher productivity, especially in knowledge-intensive firms. Reduced frictions in operational sequences following TAW use should, on their own, already add to the user firm's productivity (Hirsch and Mueller, 2012).

Secondly, TAW contracts can be used to screen for "productive" workers. Firms could engage TAWs and decide to offer regular employment contracts to those who convince by performance, as opposed to advertising vacancies and selecting applicants. Engaging TAWs would serve as a prolonged probation period. For workers, TAW could offer a stepping stone into regular employment.[6] Recruiting based on observed performance and selecting the (proven) most productive workers could hence improve firm productivity as only suitable candidates are hired. Beckmann and Kuhn (2009), for instance, find that German firms using TAW for screening purposes are more productive than firms using TAW for flexibility reasons.

On the other hand, the growth in temporary work arrangements also has negative consequences for firm productivity. Firstly, with long tenures and tight employment protection legislation, firms benefit from workers investing in building firm-specific skills (Lazonick, 2007; Kleinknecht, 2020). Productivity will thus be higher in firms which use fewer TAWs, because it is in the nature of TAWs that they possess less firm-specific skills and tacit knowledge as compared to regular employees due to the maximum duration of engagement (Hirsch and Mueller, 2012). TAWs may bring in knowledge from the outside, but they cannot acquire the same degree of firm-specific skills and (firm-specific) tacit knowledge as compared to regular employees (Kleinknecht, 2020). Secondly, greater external (numerical) flexibility could harm productivity via its influence on innovation because temporary workers will be more risk averse than regular workers on standard contracts who feel secure enough to engage in risky (innovative) activities (see Acharya *et al.*, 2013). Controlling for type of innovation, Kleinknecht *et al.* (2014) observe that a high share of temporary workers negatively impacts R&D activities for industries with routinized innovation models. Cetrulo *et al.* (2018) confirm the negative effect of flexibility (proxied by temporary employment) on innovation in terms of new product development, based on sector data for Central and Western European countries during 1998–2012. Finally, an increase in the use of TAWs could undermine the morale of the regular workers and erode trust in the employee–management relationship, when regular employees perceive TAWs as a threat to their own positions (as they cannot rule out the possibility of being replaced by new intakes) (Davis-Blake *et al.*, 2003; Beckmann and Kuhn, 2012). Higher use of TAWs could thus undermine trust in the existing industrial relations system, reducing workers' motivation and increasing labor turnover for firms (as disappointed workers leave to work elsewhere).

Using temporary contracts as a proxy for flexibility, Cirillo and Ricci (2020) find, using data for Italian firms (2007–2015), that intensive use of temporary contracts correlates with reduced labor productivity and wages. The magnitude of the effect is smaller for higher-productivity firms, suggesting that these use temporary contracts mostly for screening. Comparable findings are

[6] See Auray and Lepage-Saucier (2021) for evidence for France.

reported by Lisi and Malo (2017), who conducted a similar analysis based on sectoral data for OECD countries during 1992–2007. Bardazzi and Duranti (2016) find, based on Italian firm-level data for the period 2003–2008, that the increased use of TAWs is negatively associated with productivity, especially so in SMEs. This effect is mixed in lager firms and depends on size and sector. However, based on an analysis of a sample of German manufacturing firms (2004–2008), Nielen and Schiersch (2016) obtain negative, but mostly insignificant, coefficients for temporary employment when regressed on labor productivity. Hirsch and Mueller (2012) and Nielen and Schiersch (2014) test the effect of the share of temporary workers (or TAWs) on productivity in German firms (using data from 2003–2009 and 1999–2006, respectively) and find a hump-shaped relationship: the increased use of temporary workers is at first associated with higher productivity, but after a turning point, the greater use of temporary workers is correlated with lower productivity. Pfeifer and Weche (2020) and Beckmann and Kuhn (2009) find concave relationships between 1999–2010 and 2002–2005, respectively. To conclude, studies based on temporary employment more often than not find a negative productivity effect of external (numerical) flexibility. However, most of the data in the preceding studies only cover the years up until the financial crisis of 2007–2008. None of the existing studies address the productivity effects of TAWs in recent years and at its current levels.

In the remainder of this paper, we will econometrically evaluate the impact of TAWs on productivity growth in a panel of 4166 German firms during the recent 2010–2019 period. We focus on the share of TAWs in employment because (as we argued above) the rise in agency workers in Germany's manufacturing core represents not just some additional external flexibility at the margins of *Modell Deutschland*'s industrial relations system, but rather it signals the beginning of a larger process of transformation in which the existing industrial relations system of the core is gradually undermined (Herrero, 2021). The strategic preferences of employers, who had earlier supported standard employment contracts and traditional coordination institutions because these institutions were held to contribute to the strong technological competitiveness of their firms, are beginning to change in favor of more flexible employment contracts, including TAWs. The question is what the impact on firm-level productivity growth will be of this (gradual) shift toward more flexible, non-standard, employment, especially because high productivity growth has been the foundation of Germany's manufacturing prowess and strong international competitiveness (Storm and Naastepad, 2015). Could the OECD (2021) be right in arguing that increasing the numerical flexibility of firms aids labor productivity in this era of technological transformations? Or could the turn toward non-standard jobs (including TAWs) lead to negative productivity growth effects, which could hurt *Modell Deutschland*?

4. Data, model, and estimation methods

4.1. Data

We draw on the "IAB Establishment Panel" (published by the Institute for Employment and Research [IAB] of the Federal Employment Agency [BA]). The IAB Establishment Panel is an annual representative survey of German establishments on a wide range of topics, including general information about the establishments (not firms), the age structure and demand for skilled workers, vocational training, operational working hours, investment and innovation, and business-related aspects (FDZ, 2018). The IAB Establishment Panel covers firms of all sectors and sizes in Germany (Ellguth *et al*., 2014). The survey started with roughly 4300 interviews in 1993, but since 2001, about 15,500 firms have been surveyed yearly, based on optimum stratification sampling. It is designed for both longitudinal and cross-sectional analysis. The dataset lends itself to endeavors such as ours as it contains information on firm performance but also other critical determinants thereof.

In the following, we use the establishment data for the years 2010–2019 to estimate the relationship between labor productivity growth and the share of TAWs in total workers, while controlling for other determinants of (establishment-level) labor productivity growth.

Table 2. Variable overview

Variable		Measurement
Dependent variable	Productivity	Labor productivity growth, first difference of ln (sales/all persons engaged)
Independent variable	Temporary agency work intensity	Number of secondment workers relative to the workforce
Controls	Productivity levels	Natural logarithm of sales per person engaged
	Capital intensity growth	Growth rate of total investment per person engaged
	Academics	Share of people with an academic degree in the workforce
	Working hours	Contractual weekly working hours (full-time)
	Profit	Categorical variable indicating profitability (from 2 ["inadequate"] to 6 ["very good"])
	Age	Firm age in years
	Industry	Categorical variable capturing industry affiliation

4.2. Model

We estimate the following model:

$$\Delta lny_{it} = \beta_0 + \beta_1 TAW_{it} + \beta\, x_{it} + i_i + t_t + \varepsilon_{it}$$

Δlny_{it} is the dependent variable of this study, *labor productivity growth* at the establishment-level. It is defined as the first difference of the natural logarithm of revenues divided by the workforce[7]. We use revenues in the nominator as a proxy for outputs as the panel lacks quantitative information on alternative measures such as value added and/or profitability. The denominator, workforce, captures the firm's labor force and is the sum of the number of regular employees, freelancers, TAWs, and interns.

TAW_{it} is the independent variable, *TAW intensity*. It is defined as the number of TAWs divided by the workforce (i.e., the sum of regular employees, freelancers, TAWs, and interns—not limited to the employees of a firm).

x_{it} is a vector of control variables. As productivity is a variable with high degrees of persistence, we include its lagged value to capture this effect (Wooldridge, 2010). Further, as it is more difficult to create additional increases in productivity when productivity levels are high, we also include a lag of productivity levels. We control for the share of academics in the overall workforce (number of academics over the workforce) as differences in human resources might explain some of the productivity differences (DeFreitas and Marshall, 1998). We further control for the contractual weekly working hours as productivity per person engaged might be influenced by the number of actual working hours. It would be desirable also to include information on overtime hours, but data on actual working hours and the share of employees working part-time are only available bi-yearly. Moreover, we control for firm age (in years), capital intensity growth, and profit via a qualitative judgment of the firm's profitability by the interviewee ranging from "very good" to "defective," as the data do not contain financial information on profitability. We also include a categorical variable capturing industry affiliation (industry). Table 2 contains an overview of all variables.

4.3. Estimation methods

We estimate the model with pooled ordinary least squares (OLS), OLS with fixed effects (FE) for both firms (i_i) and years (t_t), and System generalized method of moment (GMM). With FE models, the assumption of no unobserved heterogeneity can be weakened (Brüderl and Ludwig, 2015),

[7] We use the workforce as the denominator as information on working hours is insufficiently available in the dataset. Information on working hours is collected only for full- and part-time employees on a bi-yearly basis. This and the fact that information on part-time working hours is collected in categories means that constructing an hourly denominator would require too much imputation. We are aware that others (Hoxha and Kleinknecht, 2023) have done so, however, without providing details on their procedure.

because the firm-specific constants (fixed-effects) remove all unobserved firm-specific heterogeneity. However, FE cannot eliminate bias from history effects due to time trends in the baseline outcome variable or maturation effects.

Because firms can modify the proportion of TAW workers based on their productivity levels, the fixed effect estimation could encounter endogeneity problems due to simultaneity bias. To address this endogeneity concern, we use the GMM to estimate the model (Arellano and Bond, 1991).

The Difference and System GMM dynamic panel estimators are designed for situations with many but short panels (many firms, few observations per firm), a linear functional relationship, a dynamic dependent variable, regressors that are not strictly exogenous, individual fixed effects, and heteroskedasticity and autocorrelation within individuals (Roodman, 2009). The Arellano-Bond estimator, better known as Difference GMM, transforms all regressors by differencing (Arellano and Bond, 1991). The Arellano-Bover/Blundell-Bond estimator, better known as System GMM, builds on this approach by adding the assumption that the first differences of instruments are uncorrelated with fixed-effects, making it possible to include more instruments and improving efficiency (Arellano & Bover, 1995; Blundell and Bond, 1998).

In the case of unbalanced panel datasets such as the data underlying this study, System GMM (Arellano & Bover, 1995; Blundell and Bond, 1998) is a compelling choice for estimation as the Difference GMM increases gaps in unbalanced panels. System GMM is well-suited for modeling dynamic panel data with persistent variables because it effectively captures the temporal dependencies and autocorrelation present in the data. By incorporating lagged values of the dependent variable and other covariates as instruments, System GMM can help address the persistence in the dependent variable while also mitigating potential endogeneity issues. Further, System GMM allows for the inclusion of time-invariant regressors, which typically disappear in Difference GMM (Roodman, 2009).

Following Roodman (2009), in the OLS estimates, the lagged dependent variable is positively correlated with the error term, likely biasing the coefficient upward. The opposite is the case in the fixed effects estimates. The coefficients for the lag of the dependent variable obtained with GMM should hence fall in between those estimates. To arrive at a correctly specified model, we begin with the moment conditions that need the fewest assumptions and add instruments one by one (Göbel and Zwick, 2012; Kampelmann and Rycx, 2012). We use the Hansen test (Hansen, 1982) to assess the validity of additional instruments and the Arellano-Bond test (Arellano and Bond, 1991) for second-order autocorrelation in the first-differenced errors to assess the reliability of the estimates. We opt for the most parsimonious model that satisfies both requirements.

5. Empirical results

We first describe the data and then estimate panel regression models according to the estimation methods described in Section 4.3. Next, we probe the robustness of our results by testing alternative specifications of the models.

5.1. Descriptive statistics

The final sample contains 13,197 observations across 4166 firms. Annex 1 contains information on data preparation. Table 3 contains summary statistics. The average labor productivity growth is 0.0014 (0.14%). The standard deviation of 0.25 indicates that the data show a sufficient spread among firms with low and high labor productivity growth. Minima and maxima indicate that labor productivity can decrease by roughly 240% and increase by over 411%.

The average workforce has a TAW intensity of 0.0183 (1.83%). The maximum value shows that it is possible to have almost 70% of staff as temporary agents. The standard deviation of roughly three times the mean indicates that most TAW intensities are low, with some firms using high TAW intensities. Both between and within standard deviations are relatively high compared to the overall standard deviation, indicating that TAW intensities vary both within and across groups.

Table 3. Summary statistics

Variable		Mean	Std. Dev.	Min	Max
Labor productivity growth	Overall	0.0014	0.2532	−2.4071	4.1107
	Between		0.2082	−2.2300	4.1107
	Within		0.2117	−2.3472	2.3185
Temporary agency work intensity	Overall	0.0183	0.0538	0.0000	0.6961
	Between		0.0447	0.0000	0.4682
	Within		0.0264	−0.3338	0.5404
Capital intensity growth	Overall	1.5669	16.7844	−1.0000	1374.9560
	Between		10.4160	−0.9995	416.3070
	Within		14.5015	−273.7284	1101.5700
Share of academics	Overall	0.1005	0.1773	0.0000	1.0000
	Between		0.1720	0.0000	1.0000
	Within		0.0469	−0.5622	0.6672
Company age	Overall	16.2810	7.0287	0.0000	29.0000
	Between		7.1038	1.0000	29.0000
	Within		2.1499	−2.0524	32.9476
Profitability	Overall	4.5654	0.9548	2.0000	6.0000
	Between		0.8500	2.0000	6.0000
	Within		0.5767	1.1654	7.7654
Working hours	Overall	39.5821	1.6477	0.0000	70.0000
	Between		1.7772	0.0000	58.3333
	Within		0.6911	26.2487	59.3821
Productivity level (lag)	Overall	11.4224	0.8389	8.2630	15.8535
	Between		0.8510	8.5214	15.3082
	Within		0.1646	9.5751	15.5341

There are 13,197 observations across 4166 firms with an average of 3.17 observations per firm. Next to the global mean ($\bar{\bar{x}}$), the summary statistic decomposes the variable x_{it} into between ($\bar{x}_i$) and within ($x_{it} - \bar{x}_i + \bar{\bar{x}}$), adding the global mean back in to make the results comparable (StataCorp, 2017).

Average (gross) capital intensity growth is 1.56 (156%), with strong variations both between and within firms. The standard deviation of more than 10 times the mean indicates strong variability, as also reflected in minima and maxima. On average, some 10% of employees have an academic degree, with strong between-firm differences, as indicated by the low within-group standard deviation. The average company is 16 years old.

Profits is, on average, between satisfying (4) and good (5). The standard deviation of 0.9548 suggests that many observations are around these values.

Full-time contractual working hours range between 0 and 70 hours, with an average of 39.6 weekly contractual hours. The small standard deviation reveals that little variation within and across firms exists.

Productivity levels average 11.4224 and indicate an average productivity of 92,000 Euro per person engaged (exponentiated). Minima and maxima indicate that the data encompass both marginal and highly productive businesses. The maxima indicate strong fluctuations, which are especially seen in smaller-than-average firms.

Table 4 shows how the firms in the data set are distributed across TAW-intensity categories. Most firms do not use TAWs (ca. 80% of all observations). Of the TAW-using firms, roughly 88% use TAW intensities of up to 0.2, while 12% exceed TAW intensities of 0.2.

5.2. Estimations results

We now estimate the effects of deploying TAWs on firm labor productivity. Table 5 contains models estimated with OLS (model 1), OLS with fixed effects (model 2), and System GMM (models 3 and 4). Next to the main variable of interest (TAW intensity), we include a squared term of TAW intensity to capture non-linearities (for reasons explained above; see also Hirsch and Mueller (2012)). We further include a 1 year lag of the dependent variable, and control for 1 year lag of productivity levels. The non-lagged control variables are firm age, capital intensity growth, profitability, share of academics, and contractual weekly working hours.

Table 4. Distribution of temporary agency work (TAW) intensities (10,533 without TAW; 2664 with TAW)

TAW intensity category	Number of observations
$TAW = 0$	10,533
$0 \leq TAW\ int < 0.025$	590
$0.025 \leq TAW\ int < 0.05$	541
$0.\ 05 \leq TAW\ int < 0.075$	387
$0.075 \leq TAW\ int < 0.1$	281
$0.1 \leq TAW\ int < 0.125$	196
$0.125 \leq TAW\ int < 0.15$	175
$0.15 \leq TAW\ int < 0.175$	100
$0.175 \leq TAW\ int < 0.2$	74
$TAW\ int \geq 0.2$	320

The estimates for the lag of the dependent variable obtained with System GMM (models 3 and 4 in Table 5) indeed fall in between the ones obtained with OLS and OLS with fixed effects (model 1 and 2, respectively). This result is expected as explained in Section 4.3.

We first test for a linear relationship between TAW intensity and labor productivity growth. Model 3, estimated with System GMM, shows a negative coefficient for TAW intensity (–0.2280), suggesting higher TAW intensities are, on average, associated with lower productivity growth. One percentage point change in TAW intensity is associated with a 0.228% decrease in labor productivity growth. Testing for a non-linear relationship between TAW intensity and labor productivity growth, the preferred model 4 suggests a hump-shaped effect, with highly significant coefficients and a negative sign for the squared term. The coefficients for the linear (0.7026) and quadratic term (–3.3544) translate into a turning point at roughly 10.5% TAW intensity, as illustrated in Figure 2.

Models 1 and 2[8] broadly confirm these results. Across both models, the squared terms of TAW intensity are highly significant with a negative sign, suggesting a hump-shaped relationship between TAW intensity and productivity growth. The linear term is only significant in model 1.

The controls behave as expected. The lag of the dependent variable, labor productivity growth, and the lag of productivity levels have negative and highly significant coefficients across the board. Higher productivity levels mean that additional productivity growth is more difficult to achieve, as low-hanging fruit has probably already been picked.

Capital intensity growth is positive as expected because more elaborate and modern capital leads to higher productivity growth. Significance is lost in the GMM estimations though the estimate remains positive. However, the lagged productivity measures may capture parts of this effect, explaining its insignificance at conventional levels.

The share of employees with an academic degree in the labor force is positively associated with labor productivity growth. Firms with a higher-educated workforce may be closer to the knowledge frontier and be more able to translate knowledge gains into productivity-enhancing modifications. Firm age as a control is insignificant. Profit, as a qualitative judgment of profitability, indicates a more satisfactory profit situation and implies more means and opportunities to engage in productivity-increasing activities, in line with the highly significant and positive coefficient (Lindbeck, 1983).[9] Working hours, with mostly negative and significant coefficients, indicate that higher weekly working hours are associated with lower productivity growth.

We further probe the results in five more ways. First, we also test for the effect of different levels of TAW intensity on labor productivity growth based on dummies for TAW intensity ranges

[8] To establish whether time fixed-effects are necessary, we tested all models with a joint test to see whether the year dummies are equal to zero (Torres-Reyna, 2007). The null hypothesis (the coefficients of the year dummies are jointly equal to zero) was rejected in all models. Each model was also tested for group-wise heteroskedasticity using the Modified Wald statistic. The rejection of the null (homoscedasticity) led to the specification of robust standard errors in all models.

[9] Lindbeck (1983) argues that lower profitability is associated with slower output growth as past or present products might become unprofitable. Moreover, and provided that the required rate of return remains constant, one would expect a decline in investment growth. Nonetheless, profitability fluctuations that do not fall short of certain satisfactory profitability level may only moderately affect investment growth.

Table 5. Labor productivity growth on TAW intensity: OLS and GMM estimates

		Dependent variable: labor productivity growth			
Variable		(1) OLS	(2) OLS FE	(3)[a] System GMM	(4)[a] System GMM
Productivity growth lag		−0.2695***	−0.0249*	−0.1592***	−0.1583***
		(0.0168)	(0.0139)	(0.0197)	(0.0198)
Productivity level lag		−0.0596***	−0.8260***	−0.3345***	−0.3334***
		(0.0037)	(0.0263)	(0.0499)	(0.0500)
TAW intensity		0.2771**	0.1690	−0.2280**	0.7026***
		(0.1102)	(0.1839)	(0.0926)	(0.1671)
TAW intensity squared		−1.9065***	−2.7109***		−3.3544***
		(0.4162)	(0.5651)		(0.4551)
Capital intensity growth		0.0007*	0.0003**	0.0005	0.0005
		(0.0004)	(0.0001)	(0.0003)	(0.0004)
Share of academics		0.0545***	0.0816	0.2727***	0.2691***
		(0.0155)	(0.0508)	(0.0463)	(0.0459)
Firm age		−0.0004	−0.0024	0.0006	0.0005
		(0.0003)	(0.0017)	(0.0006)	(0.0006)
Profit	Inadequate	Base	Base	Base	Base
	Sufficient	0.0406***	0.0487***	0.0728***	0.0719***
		(0.0137)	(0.0147)	(0.0189)	(0.0189)
	Satisfying	0.0578***	0.0860***	0.1076***	0.1066***
		(0.0122)	(0.0143)	(0.0189)	(0.0188)
	Good	0.0886***	0.1456***	0.1659***	0.1643***
		(0.0118)	(0.0147)	(0.0193)	(0.0193)
	Very good	0.1311***	0.1903***	0.2197***	0.2169***
		(0.0132)	(0.0172)	(0.0226)	(0.0226)
Working hours		−0.0034**	0.0008	−0.0068***	−0.0065***
		(0.0014)	(0.0028)	(0.0024)	(0.0024)
Industry category, year dummies		Yes, yes	Yes, yes	Yes, yes	Yes, yes
Constant		0.7491***	9.3537***	4.0293***	4.0047***
		(0.0724)	(0.3264)	(0.6042)	(0.6037)
AR(1), AR(2)				0.000/0.284	0.000/0.285
Hansen				0.091	0.090
Instrument count				421	422
Wald chi(2)				889.6	969.33
Prob. chi(2)				0.000	0.000
R^2		0.1446	0.4655		
Observations, firms		13,197/4166	13,197/4166	13,197/4166	13,197/4166

Robust standard errors in parentheses.
***$P < 0.01$,
**$P < 0.05$,
*$P < 0.1$. Monetary values in 2015 Euros.
Period: 2010–2019. Model (1) is estimated with pooled OLS, (2) with OLS and fixed-effects, (3) and (4) with System GMM. FE, fixed effects; GMM, generalized method of moment; OLS, ordinary least squares; TAW, temporary agency work.
[a]Productivity growth lag, productivity level lag, and profit are included as gmmstyle instruments, all else as ivstyle instruments.
Explanation of variables: see Table 2.

(e.g., $0 \leq TAW\ int < 0.025$, see model 5 in Table 6) in increments of 2.5 percentage points for TAW intensities between 0% and 20%, and exceeding 20%. Coefficients for TAW categories are significant for low and higher categories but insignificant for TAW intensities exceeding 0.075 (7.5%) and below 0.2 (20%). For TAW intensities exceeding 0.2 (20%), we find a highly significant and negative effect. While not strictly resembling the hump-shaped effect found in the quadratic specification in model 4, the results based on TAW intensity categories do suggest positive productivity growth effects at low values of TAW intensity (left of the turning point), no effects right of the turning point, and negative effects when TAW intensity exceeds 0.2 (20%).

Table 6. Labor productivity growth and TAW intensity: alternative specifications: GMM estimates

Variable		Dependent variable: labor productivity growth (5)
Productivity growth lag		−0.1623***
		(0.0197)
Productivity level lag		−0.3234***
		(0.0490)
TAW categories		
TAW = 0		(base)
$0 \leq TAW\ int < 0.025$		0.0623***
		(0.0150)
$0.025 \leq TAW\ int < 0.05$		0.0439***
		(0.0142)
$0.05 \leq TAW\ int < 0.075$		0.0462***
		(0.0163)
$0.075 \leq TAW\ int < 0.1$		0.0381**
		(0.0183)
$0.1 \leq TAW\ int < 0.125$		0.0078
		(0.0208)
$0.125 \leq TAW\ int < 0.15$		0.0110
		(0.0195)
$0.15 \leq TAW\ int < 0.175$		−0.0006
		(0.00261)
$0.175 \leq TAW\ int < 0.2$		−0.0480
		(0.0355)
$TAW\ int \geq 0.2$		−0.0740***
		(0.0239)
Capital intensity growth		0.0005
		(0.0004)
Share of academics		0.2605***
		(0.0455)
Firm age		0.0004
		(0.0006)
Profit	Inadequate	Base
	Sufficient	0.0711***
		(0.0189)
	Satisfying	0.1053***
		(0.0188)
	Good	0.1640***
		(0.0192)
	Very good	0.2186***
		(0.0225)
Working hours		−0.0061**
		(0.0024)
Industry category, year dummies		Yes, yes
Constant		3.8770***
		(0.5902)
Hansen		0.057
AR(1)/AR(2)		0.000/0.220
Instrument count		429
Wald test		896.94
Prob chi(2)		0.000
Number of observations/groups		13,197/4166

Robust standard errors in parentheses.
***$P < 0.01$,
**$P < 0.05$. Monetary values in 2015 Euros.
Period: 2010–2019. Productivity growth lag, productivity level lag, and profit are included as gmmstyle instruments, all else as ivstyle instruments. GMM, generalized method of moment; TAW, temporary agency work.
Explanation of variables: see Table 2.

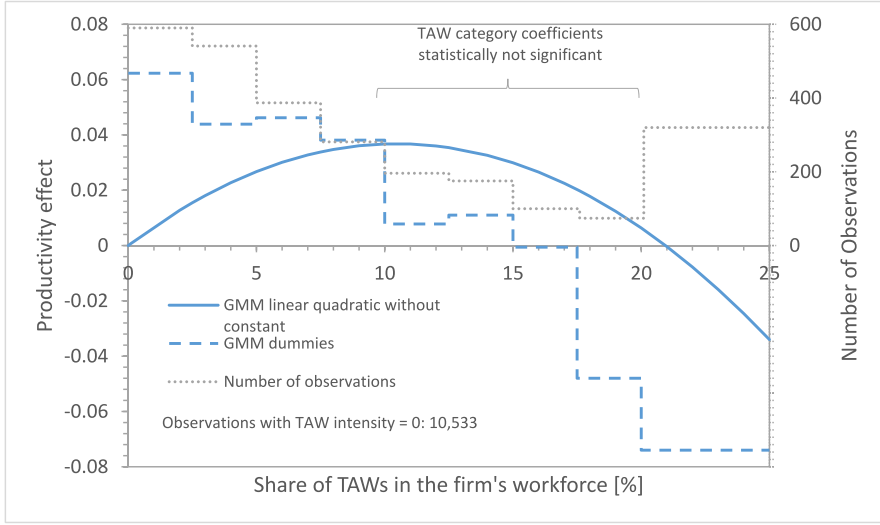

Figure 2. The effect of TAW intensity on labor productivity growth based on regressions in Tables 5 and 6

Second, the hump shape should be located well within the relevant data range (Haans *et al.*, 2016). The average firm has a TAW intensity of 0.0183 (1.83%) (with a standard deviation of 0.054). Figure 2 suggests the turning point at 10.5% TAW intensity indeed is located within the data range, and also within a practically relevant part of it. We also estimate 95% confidence intervals for the turning point (0.0777; 0.1317),[10] and this interval, too, falls within a relevant part of the data range.

Third, we split the data at the turning point estimated in model 4 and created two sub-samples. To confirm a hump-shaped relationship, one would expect a significant and positive coefficient for TAW intensity to the left of the turning point, and a significant and negative coefficient to the right. And indeed, we obtain significant coefficients of 0.4989 ($P = 0.0234$) and –0.6440[11] ($P = 0.0040$), respectively (see Table A1 in Annex 2, models 6 and 7).

Fourth, we computed a model resembling model 2 with random effects (RE) (reported in Table A2 in Annex 2).[12] The between estimator of model 2 could fail to include random slopes, generating biased standard errors. The estimates result in a positive coefficient for TAW intensity and a negative coefficient for its squared term, qualitatively supporting the current estimates.

Fifth, we test for the exclusion of outliers. We limited the data to observations that fall within two standard deviations below or above mean productivity growth and re-calculated model 4 of Table 5. Qualitatively, the conclusion remains the same—coefficients of 0.5010 and –2.6331 for the linear and quadratic terms, respectively, indicate a turning point near 9.5% TAW intensity (see Table A1).

Taken together, we conclude that the productivity effects of TAW are hump shaped. Figure 2 illustrates the findings across different models. The solid line illustrates the curvilinear productivity effect (primary vertical axis) of TAW intensity over relevant TAW shares. The dashed line shows productivity effects (primary vertical axis) across TAW intensity categories in increments of 2.5% (baseline: no TAWs). The dotted line depicts the number of observations (secondary vertical axis) per TAW intensity category. Low shares of TAWs in the labor force can be beneficial

[10] Estimated with Nonlinear Combinations of Parameters (Stata command: nlcom).

[11] Note that the remaining data available for system GMM do not suffice to re-estimate the baseline model 4 in Table 5. If we were to use this specification, the number of instruments would exceed the number of groups. Further, the Hansen statistic for the estimates based on the right-hand sample were exactly 1.000, further flagging problems. Hence, we have reduced the number of controls to a minimum.

[12] We thank an anonymous reviewer for raising this point.

Table 7. Number of firms with temporary agency work (TAW) intensity ≠ 0 by industry classification (top 10, total of 1791 observations)

Industry classification		TAW intensity ≠ 0			TAW intensity = 0	
		No. of observations	Workforce (mean)	TAW intensity (mean)	No. of observations	Workforce (mean)
14	Mechanical engineering	305	191	0.0711	322	64.8
11	Manufacturing of metal products; steel/light-metal engineering	297	133.6	0.1063	348	40
8	Manufacturing of rubber/plastics products	202	170.5	0.1084	135	64.2
9	Manufacturing of glass/ceramics; processing of stone and industrial minerals	169	133.9	0.0976	139	73.5
19	Building installation, finishing trade	156	70.2	0.135	738	29.7
10	Manufacturing of basic metals; fabricated metal products	148	254.3	0.089	190	60
15	Manufacturing of motor vehicles/components; other vehicle production	144	900.7	0.1247	129	100.3
3	Energy/water supply; waste disposal, etc.	134	226.2	0.06697	228	95.5
7	Manufacturing of chemical/pharmaceutical products; coking; mineral oil processing	123	404.9	0.06416	202	79
13	Manufacturing of electrical equipment	113	215.4	0.118	148	48.4

but the benefits peak at roughly 10.5% and turn into a disadvantage when brought to levels exceeding 20%.

When interpreting these results, it is important to bear in mind that the majority of German firms in the panel dataset resort to TAW to such an extent that the estimated productivity effect is positive. The average share of temp agency workers in the labor force rose from 1.4% during 2000–2008 to 2.1% during 2009–2019 (based on Destatis data reported in Figure 1). This represents a movement along the upward-sloping part of the inverted U-curve in Figure 2, which peaks only at a TAW intensity of 10.5%. Hence, based on the results from our preferred System GMM specification, we conclude that the increase in the average share of temp agency workers in the labor force has, on average, enabled German firms to increase labor productivity. In fact, using the average TAW intensities for the periods 2000–2008 and 2010–2019, we find that the increase in TAW share, and the resulting increase in numerical flexibility for firms, has raised average firm-level labor productivity growth by around 0.4 points in the latter period compared to the period 2000–2008; the true effect may be smaller due to changes in control variables that are not accounted for in this back-of-the-envelope calculation. This average effect is economically important, especially in view of the fact that average growth of gross output per worker in Germany was considerably lower during 2010–2019 than during 2000–2008.

However, we note that the mean of TAW intensity for firms with TAWs is 0.0908 (9.08%) compared to the overall mean of 0.0183 (1.83%). Table 7 lists the 10 industry categories that use TAWs most heavily. It lists average TAW intensities for TAW-using firms and compares the workforce in TAW-using versus non-TAW-using firms. It shows that TAW-using firms are, on average, bigger in terms of workforce. These 10 categories account for 67% of all firms with TAWs, and mostly represent manufacturing firms.

On average, firms relying on temp agency workers are, therefore, operating quite close to the turning point of 10.5% (see Table 7) and would be ill-advised to step up TAW use. Turning to the (more) heavy TAW users, roughly one-third of the TAW-using firms in the panel data set are found to have a TAW intensity that exceeds the turning point of 10.5%. Many of these firms belong to Germany's export-oriented manufacturing core (Table 7). This shows that for these firms, the heavy use of temp agency workers did have a negative impact on labor productivity growth. For circa 10% of the firms, TAW intensities in excess of 21% are even associated with negative productivity growth. These findings reveal that while increased (numerical) flexibility will be good for productivity growth, firms must be careful, because a heavy reliance on TAW will hurt productivity growth, arguably because TAWs possess less firm-specific knowledge, and the motivation of permanent workers may suffer. This result should be heeded by policy-making bodies such as the OECD (2021) and the European Commission (Servoz, 2019), which strongly emphasize the need for increasing the flexibility of labor markets in order to help firms navigate the rapid structural changes arising from the COVID19 pandemic, the transition to a greener economy, and the geopolitical fragmentation of the world economy and global supply chains. Too much flexibility may not help firms to respond to these challenges.

6. Discussion and conclusion

The longer-run effects of Germany's Hartz reforms continue to be widely debated (Odendahl, 2017; Herrero, 2021). This debate has centered mostly on the effects of the Harz reforms and the included labor market flexibilization on Germany's unemployment rate, job growth, wage growth, and the cost-competitiveness of Germany's export-oriented manufacturing sector (Dadush, 2010; Ma and McCauley, 2014; Herrero, 2021). It is less clear, however, what the effect has been of the flexibility measures introduced as part of the Hartz reforms on Germany's labor productivity growth.

The present study contributes to the small, though rising, number of microeconometric analyses of the productivity effects of labor market deregulation in Germany, based on an analysis of data from a large firm-level panel of 4166 firms of the German IAB. We do this by focusing in particular on the proportion of workers in flexible work arrangements and especially TAW in the period 2010–2019, which has grown spectacularly during this period.

We conclude that low shares of TAWs in the labor force benefit productivity, but the benefits peak at roughly 10.5% and turn into a disadvantage when brought to levels exceeding 20%. This finding is robust to several alternative specifications. For the majority of German firms in our panel dataset, the increased numerical flexibility provided by the use of TAWs is found to have raised firm-level productivity growth. If we extrapolate the (average) panel results to the aggregate economy, the step-up in the use of temp agency workers can be estimated to have raised labor productivity growth by around 0.5 percentage points.[13] This average effect is economically important as the average growth of gross output per worker in Germany has been declining over time. The results also demonstrate the added value of doing a microeconomic (firm-level) analysis—because the decline in Germany's aggregate labor productivity growth is obscuring the positive impact on firm productivity performance of greater numerical flexibility for firms.

However, the findings also show that if numerical flexibility is carried too far, productivity growth will suffer. Roughly one-third of the firms in our panel data set that use TAWs are found to have a TAW intensity that exceeds the turning point of 10.5%. For these firms, many of which are part of Germany's manufacturing core, the heavy use of temp agency workers has a negative impact on labor productivity growth. This risk should be heeded by policy-making bodies such as the OECD (2021) and the European Commission (Servoz, 2019), which emphasize, in a rather unqualified manner, the need for more labor market flexibility to help firms grow in an increasingly turbulent global economy. The findings resonate with others who find a negative effect of TAW use on productivity growth (Hoxha and Kleinknecht, 2023). Further increases in

[13] In this extrapolation, we use the two estimated coefficients for TAW intensity of model (4) in Table 5 and assume (based on Destatis data) that the average TAW intensity in Germany increased from 1.5% during 2000–2008 to 2.3% during 2009–2019.

TAW use by intensive users will hurt productivity growth. We confirm the results of earlier studies (Beckmann and Kuhn, 2009; Hirsch and Mueller, 2012). These earlier studies use data for the early years following the Hartz reforms in which the effects of the Hartz reforms are likely not to have manifested themselves fully. We use data from a longer period (2010–2019), during which the use of temp agency workers expanded considerably, and, hence, are better able to assess the structural impacts of the reforms.

The estimates also lend support to studies reporting a negative effect of structural reforms on productivity and innovation in routinized innovation regimes (Kleinknecht *et al*., 2014; Vergeer *et al*., 2015; Wachsen and Blind, 2016). Seeing the recent (skilled) worker shortages, Gallas (2024) argued that TAW is under pressure. With more vacant positions, fewer job seekers feel compelled to accept the usually inferior working conditions at temporary work agencies and enter traditional employment relations instead. In the light of our findings, this trend is to be welcomed.

The findings leave room for future research. First, by computing the TAW intensity, we have colored all TAWs with the same brush. Differences in skill, education, experience, and length of stay at the host company are not observed and not reflected in the results. Future research may look at productivity effects of TAW use depending on the characteristics of the specific TAWs at specific companies. To our knowledge, no studies address labor market flexibility at the person level rather than the firm level. This may help to identify those flexible work arrangements that harm productivity.

Second, the estimations in this study are based on revenue growth per person engaged. Calculating labor productivity based on hours worked in the denominator instead of persons engaged would have been desirable but was not feasible due to missing data for many observations. We control for weekly contractual working hours but had to rely on fixed effects for other firm-specific differences such as the share of part-time employees.

Third, as we have argued earlier, firms can rid themselves of TAWs with priority compared to regular employees. Being able to adjust the labor force more flexibly can make short-term productivity figures look rosier than they are based on a bookkeeping effect.[14] This implies that higher revenues per employee do not necessarily indicate higher productivity in terms of favorable technical change. The average length (roughly four observations per firm) of panels in the data set is rather short, so such effects cannot be ruled out. It may be that the more long-term dynamics that underlie productivity effects via technical change are less reflected in the rather short panels. Such an effect would bias the results upward, favoring a positive impact of TAW use on productivity growth.

Fourth, there are large between-firm differences in the use of TAW. TAW intensity is equal to zero for almost 80% of all observations. Further, the mean of TAW intensity for firms with TAWs is 0.0908 (9.08%) compared to the overall mean of 0.0183 (1.83%). This raises the question of why certain firms tend to rely significantly more on TAWs than others. Differential TAW intensities are likely to be caused by differences in the importance of the cumulativeness of (firm-specific) knowledge between firms (Kleinknecht *et al*., 2014) or by variations in the type of innovation (incremental versus radical) that firms engage in (Kleinknecht, 2020). However, this is a key issue that may be further explored by future research.

A final qualification concerns the level to analysis. It is important to acknowledge that this analysis takes place at the firm level and hence disregards all potential costs and benefits of TAW that manifest themselves outside the firm boundaries. In this respect, although moderate TAW intensities can be beneficial to firm-level productivity, we do not factor in the wider implications TAW may have on society. For instance, TAWs often work for lower wages than their regularly employed peers and may face more job and income uncertainty due to frequently changing clients, commuting costs, and the like.

[14] We thank an anonymous reviewer for raising this point.

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Annex 1

Data preparation

Although the data are available for the years 1993–2016, we are limited regarding data on TAWs, which had not been included in the survey during the years 1998–2002. As the use of TAWs took off in the early 2000s, we decided to use that part of the panel.

When using the data, one must be aware that the questions in the questionnaire are, in part, asked for different years. Questions pertaining to the use of freelancers or TAWs, for example, are collected for the reference day June 30 (Fischer *et al.* 2014). On the other hand, questions regarding the business volume of a company are framed loosely to accommodate for different financial years amongst the firms in the sample. It is stated that this question would normally refer to the business volume of the previous financial year. Similarly, the questionnaire captures the volume of the investments of the previous financial year. Therefore, there is a need to transfer the data to the same wave of the questionnaire. Data collected for the previous financial year, thereby, shorten the available waves by one year. We use Gross Domestic Product deflators to bring all monetary values to the base year of 2015. Furthermore, the sample had to be restricted to those observations that include information on crucial variables. Sometimes, it is indicated that TAWs, interns, or freelancers were used, but no number is provided. These observations were excluded from the analysis.

Annex 2
Additional regression results

Table A1. Labor productivity growth and TAW intensity: probing the hump-shaped relationship by splitting the data at the turning point

		(6)	(7)	(8)
		Left of turning point	Right of turning point	Excluding outliers
Variable		System GMM	System GMM	System GMM
Productivity growth lag		−0.1542***	−0.3150***	−0.1535***
		(0.0201)	(0.1167)	(0.2031)
Productivity level lag		−0.3117***	−0.2128**	−0.2622***
		(0.0488)	(0.0973)	(0.4390)
TAW intensity		0.4989**	−0.7406***	0.5010***
		(0.2200)	(0.1813)	(0.1531)
TAW intensity squared				−2.6331***
				(0.4910)
Capital intensity growth		0.0005		0.0003*
		(0.0004)		(0.0002)
Share of academics		0.2339***	0.3579	0.1955***
		(0.0450)	(0.2482)	(0.0404)
Firm age		0.0007		0.0005
		(0.0006)		(0.0005)
Profit	Inadequate	(base)		(base)
	Sufficient	0.0691***		0.0545***
		(0.0202)		(0.0172)
	Satisfying	0.1085***		0.1002***
		(0.0192)		(0.0170)
	Good	0.1667***		0.1417***
		(0.0199)		(0.0172)
	Very good	0.2201***		0.1813***
		(0.0232)		(0.0195)
Working hours		−0.0057**	−0.0103	−0.0075***
		(0.0025)	(0.0135)	(0.0021)
Industry dummies, year dummies		Yes, yes	No, yes	Yes, yes
Constant		3.7147***	3.0360**	3.2324***
		(0.5850)	(1.5000)	(0.5436)
Hansen		0.138	0.852	0.191
AR(1)/AR(2)		0.000/0.087	0.089/0.621	0.000/0.026
Instrument count		421	104	422
Number of observations/groups		12,154/3982	481/208	12,282/3936
Wald chi(2)		647.20	56.23	791.26
Prob chi(2)		0.000	0.000	0.000

Robust standard errors in parentheses.
***$P < 0.01$,
**$P < 0.05$,
*$P < 0.1$. Monetary values in 2015 Euros.
Period: 2010–2019. Estimated with System GMM.
Productivity growth lag, productivity level lag, and profit are included as gmmstyle instruments, all else as ivstyle instruments. GMM, generalized method of moment; TAW, temporary agency work.
Explanation of variables: see Table 2.

Table A2. Labor productivity growth and TAW intensity: random effects (RE) estimations

Variable		Dependent variable: labor productivity growth (8) Generalized Least Squares RE
Productivity growth lag		−0.2924***
		(0.0142)
Productivity level lag		−0.1195***
		(0.0060)
TAW intensity		0.3634**
		(0.1370)
TAW intensity squared		−2.8314***
		(0.4756)
Capital intensity growth		0.0006*
		(0.0003)
Share of academics		0.1012***
		(0.0213)
Firm age		−0.0004
		(0.0004)
Profit	Inadequate	base
	Sufficient	0.0457***
		(0.0138)
	Satisfying	0.0699***
		(0.0127)
	Good	0.1120***
		(0.0125)
	Very good	0.1627***
		(0.0145)
Working hours		−0.0031*
		(0.0017)
Industry category, year dummies		Yes
Constant		1.4199***
		(0.0994)
Wald-chi(2)		1488.78
Prob chi(2)		0.000
Observations, firms		13,197/4166

Robust standard errors in parentheses.
***$P < 0.01$,
**$P < 0.05$,
*$P < 0.1$. Monetary values in 2015 Euros.
Period: 2010–2019. Model (1) is estimated with pooled GLS and random effects. TAW, temporary agency work.
Explanation of variables: see Table 2.

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