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**A genie in a bottle?
Globalisation, competition
and inflation**

**Dan Andrews,
Peter Gal,
William Witheridge**

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A GENIE IN A BOTTLE? GLOBALISATION, COMPETITION AND INFLATION

ECONOMICS DEPARTMENT WORKING PAPERS No. 1462

By Dan Andrews, Peter Gal and William Witheridge

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ABSTRACT/RÉSUMÉ

A Genie in a Bottle? Globalisation, Competition and Inflation

Declining inflation in many countries over the past few decades at the same time as rising global competition has led to a debate on the importance of globalisation for domestic inflation. This paper explores the implications of global value chain (GVC) integration and market contestability for inflation using a range of industry-level and micro-data sources. We provide evidence that rising participation in GVCs has placed downward pressure on producer price inflation, by increasing the ability of firms to substitute domestic inputs with cheaper foreign equivalents. We investigate the channels, which suggests that increased GVC participation contributed to lower inflation via downward pressures on unit labour costs – by raising productivity and reducing wages – in the importing country, especially when low-wage countries are integrated in supply chains. We then present industry-level evidence to support the conjecture that a higher level of GVC integration dampens producer price inflation by accentuating the impact of global economic slack on domestic inflation. However, we also find an increasing trend in mark-ups, suggestive of rising market power, particularly in services sectors. Thus, looking forward, there is a risk that stalling globalisation since the crisis, coupled with stronger aggregate demand and declining market contestability, could lead to inflationary pressures in the medium term, thereby letting the inflation genie out of the bottle.

JEL classification: F60, E31, L16

Keywords: globalisation, competition, inflation, market power

Un génie dans sa lampe ? Mondialisation, concurrence et inflation

Le recul de l'inflation observé dans de nombreux pays de l'OCDE depuis plusieurs décennies parallèlement au renforcement de la concurrence à l'échelle mondiale a débouché sur un débat concernant l'importance de la mondialisation pour l'inflation interne. Nous explorons dans ce document les répercussions de l'intégration dans les chaînes de valeur mondiales (CVM) et de la contestabilité des marchés sur l'inflation, en utilisant différentes sources de données sectorielles et de microdonnées. Nous montrons que l'augmentation de la participation aux CVM exerce des pressions à la baisse sur l'inflation mesurée par les prix à la production, en renforçant la capacité des entreprises de remplacer des intrants nationaux par des équivalents étrangers moins coûteux. Notre analyse des canaux de transmission laisse à penser que l'augmentation de la participation aux CVM a contribué à réduire l'inflation en exerçant des pressions à la baisse sur les coûts unitaires de main-d'œuvre – résultant d'une hausse de la productivité et d'une baisse des salaires – dans les pays importateurs, en particulier lors de l'intégration de pays à bas salaires dans les chaînes d'approvisionnement. Nous présentons ensuite des données sectorielles pour étayer l'hypothèse selon laquelle une plus forte intégration dans les CVM atténue la hausse des prix à la production en accentuant l'effet du volant de ressources économiques inemployées au niveau mondial sur l'inflation interne. Néanmoins, nous mettons également en évidence une tendance à la hausse des marges des entreprises, qui laisse augurer un renforcement de leur pouvoir de marché, en particulier dans les secteurs de services. Par conséquent, dans les temps à venir, il est à craindre que l'enlisement de la mondialisation depuis la crise, conjugué à un renforcement de la demande globale et à un recul de la contestabilité des marchés, ne puisse déboucher sur des tensions inflationnistes à moyen terme, laissant du même coup le génie de l'inflation sortir de sa lampe.

Classification JEL : F60, E31, L16

Mots-clés : mondialisation, inflation, pouvoir de marché

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A Genie in a Bottle? Globalisation, Competition and Inflation

By Dan Andrews, Peter Gal and William Witheridge¹

1. Introduction and main findings

1. The combination of low inflationary pressures over recent years against a backdrop of strengthening aggregate demand in many OECD countries raises questions about the nature of supply-side shocks influencing the inflation process. In this context, this paper marshals a range of industry-level and micro-data sources to explore two structural forces that carry very different implications for inflation. First, we provide evidence that rising integration in global value chains (GVCs) has placed downward pressure on producer price inflation, by increasing the ability of firms to substitute domestic inputs with cheaper foreign equivalents. Second, we conjecture that there is a risk that stalling globalisation coupled with declining market contestability – and particularly rising market power – could translate into inflationary pressures in the medium term, thus letting the inflation genie out of the bottle.

2. We first examine how rising GVC integration shapes domestic inflationary pressures using cross-country industry-level data for 22 OECD countries over the period 1995-2014. To aid identification, we exploit industry-level data which allows us to control for all time-varying country-specific and global shocks. In turn, we find that increases in GVC participation – as measured by higher foreign value added content as a share of gross exports – is associated with lower producer price inflation. For example, we estimate that at its peak, the rise in GVCs reduced annual producer price inflation by 0.15 percentage points on average, but this effect is more than double in some OECD countries. Next we dig deeper into the channels, which suggests that increased GVC participation may have contributed to lower inflation via downward pressures on unit labour costs (through raising productivity and reducing wages) in the importing country, especially when low-wage countries are integrated in supply chains. These results suggest that domestic inflation in advanced economies could remain contained to the extent that the composition of GVCs continues to shift towards low-wage countries, even though the (aggregate) level of GVC integration has remained broadly unchanged since 2008.

1. Corresponding authors are: Dan Andrews (Dan.Andrews@oecd.org), Peter Gal (Peter.Gal@oecd.org) and William Witheridge (William.Witheridge@oecd.org) from the OECD Economics Department. The authors would like to thank Raphael Auer, Luiz de Mello, Andrew Filardo, David Haugh, Catherine L. Mann, Giuseppe Nicoletti, Nigel Pain, Łukasz Rawdanowicz, Dorothée Rouzet, Elena Rusticelli, David Turner and Beth Anne Wilson for their valuable comments and Isabelle Fakih and Sarah Michelson for providing helpful editorial assistance. The views expressed in this paper are those of the authors and do not necessarily reflect those of the OECD or its member countries.

3. Moreover, we present new industry-level evidence to support the conjecture that a higher level of GVC integration still dampens producer price inflation by accentuating the impact of global economic slack on domestic inflation, as recently demonstrated by Auer, Borio and Filardo (2017) using aggregate data. For example, given an average foreign output gap of -1.5 per cent in our sample in 2014, we estimate that annual producer price inflation was on average 0.25 percentage points lower in 2014 due to the observed rise in GVC integration, relative to a counterfactual where GVCs remained at 1996 levels. The corresponding figure is more than 0.5 percentage points, however, for countries that experienced a particularly large rise in GVC participation.

4. Second, if the global disinflation observed over the last few decades was partly due to structural reforms that induced more intense competition in product and labour markets (Rogoff, 2003), then it follows that evidence of declining market contestability is of concern. Accordingly, we document some emerging stylised facts from firm-level studies, which point to rising entry and exit barriers, a decline in the efficiency of reallocation and rising productivity dispersion. We then exploit harmonised cross-country firm-level data to document a statistically significant rise in mark-ups in the market services sector in OECD countries since the early 2000s. In turn, we demonstrate a robust positive correlation between producer price inflation and mark-ups within industries. This leads us to conjecture that market power – to the extent that it continues to rise – may pose an upside risk to future inflation. Finally, given that the rise in mark-ups seems particularly significant in information and communication technology (ICT) intensive services, we speculate that policy efforts to adapt pro-competitive market regulations to the digital age will not only yield benefits for long-run productivity growth but could also be desirable from a monetary policy perspective.

5. The paper proceeds as follows. The next section places our research in the context of the existing literature on globalisation, competition and inflation. Section 3 discusses the industry and firm-level data and GVC measurement issues, as well as preliminary evidence on the link between GVCs and inflation. Section 4 presents our econometric framework. Section 5 provides the results and estimated impact of the expansion of GVCs on inflation and wages and the propagation of foreign shocks. Section 6 explores the empirical link between rising market power and inflation, and Section 7 concludes.

2. Inflation, global supply chain integration and competition

6. The confluence of declining inflation in many countries over the past few decades with rising global competition has led to a debate on the importance of globalisation for domestic inflation. The rapid advance of globalisation through the 1990s up until the crisis – underpinned by technological progress and trade liberalisation – saw countries deepen trade linkages with existing markets and expand to new ones which integrated into the global economy. In particular, greater trade integration can raise competition and lower domestic prices through several channels: (i) increasing *contestability* for factors of production and markets for final goods; (ii) increasing *substitutability* by being able to shift elements of the production process across borders (Auer et al, 2017); (iii) raising *productivity* through a larger variety and cheaper imports that can be used as inputs and allowing for lower output prices (Bloom et al, 2015). The first two channels reduce prices for factors and goods and firms' production costs. Greater trade in intermediates exerts particularly strong competitive pressures compared with trade for final goods and services as they increase contestability and substitutability through the production process and are

reinforced further along the supply chain (Lombardo and Ravenna, 2014; Burstein et al, 2008).

7. But the strength and impact of global forces on domestic inflation has been debated by researchers and policy makers. Accordingly, this section reviews some of the competing findings on inflation, globalisation and competition and places our research in the context of the existing literature. It then reviews emerging firm-level evidence of declining market contestability and rising market power and the potential implications for future inflation.

2.1 *Debate on inflation, globalisation and competition*

8. In the early 2000s, the connection between globalisation and inflation through increased competition and lower production costs – often referred to as the ‘global competition hypothesis’ – rose to prominence (Rogoff, 2003). Global trade rose significantly as a share of GDP and this global integration and deregulation led to higher imports as a share of production, particularly from Asia and notably because of China’s emergence in the world economy (Haugh et al, 2016). As well as this direct substitution to cheaper traded final and intermediate goods and services, globalisation increases competition in product and labour markets. Rogoff (2003) conjectured that these global forces were a key factor behind global disinflation, i.e. the general steadily falling inflation in advanced economies over the same period.

9. This triggered a number of empirical studies into the consequences of globalisation for inflation. Studies by the IMF (2006), OECD (2006) and Pain, Koske and Sollie (2008) found that globalisation (i.e. increased trade openness as measured by the rising share of imports in production) exerted a significant negative effect on prices in advanced economies. In turn, Borio and Filardo (2007), Bianchi and Civelli (2015) and Auer, Borio and Filardo (2017) argued that rising globalisation – especially GVC integration – accentuated the importance of global factors – particularly global economic slack – for domestic inflation, relative to domestic pressures. Yet, other analyses have disputed the relevance of this conjecture; see Ihrig et al (2010) and Yellen (2017) for the United States and ECB (2017) and Draghi (2017) for the euro area. Kamber and Wong (2018) distinguish between short-run inflation, which they find is influenced by global factors, with a smaller impact on trend inflation.

10. Our analysis departs from existing research in two main ways. First, we take GVCs explicitly into account by using the data recently provided by the joint Trade in Value Added (TiVA) initiative of the OECD and WTO (OECD-WTO, 2012), which measures at the industry-level where value is created and embodied in goods and services that are traded and consumed worldwide (Hummels, Ishii and Yi, 2001). In most previous studies, globalisation was usually measured by imports as a share of production. Industry-level GVC indicators better reflect the underlying structure of global supply chain integration, in contrast to import penetration measures which are more likely to be directly affected by cyclical factors and relative price shifts (Johnson and Noguera, 2012).

11. Second, the use of these cross-country industry-level data allows us to go beyond existing research on inflation and globalisation that is often undertaken at the country level. While this provides a useful view of the aggregate picture, the country-level approach may encounter identification problems if unobserved time-varying country-specific shocks are correlated with domestic inflation and globalisation variables. Our approach makes it possible to apply a rich fixed effects structure that can control for time-varying country-specific shocks, global industry shocks and time-invariant country-

industry features. With this in mind, the next section reviews the scarce existing industry-level studies of trade integration and inflation and other studies that explore the implications of GVCs for domestic inflation.

2.2 Existing literature

2.2.1 Globalisation and GVCs

12. Using industry-level data, IMF (2006) finds that a higher import share of production has significant negative effect on relative prices, unit labour costs and wages. This analysis uses an earlier vintage of the OECD-Structural Analysis (STAN) database and covers 13 advanced economies for 22 industries for 1987-2003. Their econometric approach is motivated by Chen, Imbs and Scott (2009), who develop a modified Melitz and Ottaviano (2008) model which relates trade openness to industry prices, productivity and mark-ups. More specifically, increased trade penetration reduces prices via economies of scale in production and the exit of inefficient firms which lowers average costs, and squeezes firm margins through competitive pressures. At the same time, Chen et al (2009) use data on manufacturing sectors in 7 advanced European economies for 1989-1999 and find that greater trade openness is associated in the short-run with lower relative prices, higher productivity and lower mark-ups. Finally, Auer and Fischer (2010) focus specifically on imports from low-wage countries for 325 manufacturing industries in the United States over 1997-2006 and find that greater import competition has reduced producer prices.

13. Using cross-country aggregate data, Auer, Borio and Filardo (2017) analyse how GVC participation – as well as the aforementioned final trade-based measures – shape the propagation of foreign slack onto domestic inflation. Similar to Borio and Filardo (2007), Auer et al (2017) use an extended Phillips curve to incorporate global slack by estimating a foreign output gap for each country (further detail is provided in Section 3). They find that as GVCs have expanded over 1982 to 2006, this global slack term has become more important relative to the domestic output gap as a determinant of domestic inflation. We adapt this approach to our industry-level investigation as set out in Section 4.

2.2.2 Competition and market power

14. Global disinflation was also attributed to deregulation of product and labour markets and the reduced role of governments in markets more generally in the 1980s and 1990s, which increased market contestability and lowered “quasi-rents” to monopolistic firms and unions (Rogoff, 2003; Blanchard and Philippon, 2003; Jean and Nicoletti, 2015). This not only resulted in a lower overall level of prices, but it also made prices (and wages) more flexible. As a consequence, the real effects of unanticipated monetary policy shocks became smaller, undermining potential pressures on central banks to inflate (Rogoff, 2003).

15. In contrast, the message that is emerging from contemporary firm-level research is that product markets in particular are becoming less contestable over the past decade. First, the decline in the share of young businesses (Criscuolo, Gal and Menon, 2014) coupled with a higher productivity threshold for entry (Andrews, Criscuolo and Gal, 2016) suggest that barriers to entry have risen. Second, both the pace of job-reallocation across businesses (“labour market fluidity”; Davis and Haltiwanger, 2014) and the extent of productivity-enhancing reallocation has declined; that is, it has become less likely that high productivity firms expand and low productivity firms contract (Decker et al, 2017)

or exit the market (Adalet McGowan, Andrews and Millot, 2017). Finally, the “best” firms are increasingly pulling away from the “rest”, both in terms of profits (Furman and Orszag, 2015) and productivity (Andrews et al, 2016), which has also underpinned an increase in wage dispersion (Berlingieri, Blanchenay and Criscuolo, 2017). While the source of these adjustment frictions that rein in the creative destruction process are still contested, it is significant that these micro-level pathologies have been more pronounced in environments where the extent of structural reform has lagged (Andrews et al, 2016; Adalet McGowan et al, 2017).

16. Taken together, these patterns are consistent with a decline in market contestability, which in turn can lead to a rise in the market power of incumbent businesses. In fact, recent firm-level evidence for the United States documents a rise in the level of mark-ups and evokes the risk of rising future inflation if this trend continues (De Loecker and Eeckhout, 2017), while rising mark-ups are also evident in other OECD countries (Calligaris, Criscuolo and Marcolini, 2018). These findings are even stronger in ICT-intensive services, which are characterised by low marginal costs leading to “winner-takes-most” dynamics. This can lead to substantial network effects among consumers, hence the “winner” businesses can achieve greater market power.² The growing importance of ICT-based activities in the economy, as well as increasing market power in those activities, present challenges to anti-trust and regulatory policies but also poses a potential upside risk to medium- to long-run developments in inflation.

3. Data and preliminary evidence

3.1 Data description

17. This paper exploits harmonised cross-country industry-level data, sourced from three recently released databases: the OECD-StrUctural ANalysis (STAN) database, the OECD-Trade in Value-Added (TiVA) database and the OECD-TiVA Nowcast database. Our dependent variables – i.e. prices, unit labour costs, wages and labour productivity – are drawn from STAN, while we exploit the TiVA databases because measuring trade in value-added terms provides a clearer and more nuanced picture of global integration than gross trade flows. Our final database contains industry producer prices³, unit labour costs, wages, labour productivity and GVC indicators covering 22 OECD countries⁴ annually over the period 1995 to 2014 for 33 industries at the 2-digit level. This provides almost 12,000 country-industry-year observations in the baseline specification, which focuses on the link between producer prices and GVC indicators at the industry level. Notably, we combine these data with industry mark-ups estimated using firm-level data.

2. The finding that mark-ups rise more steeply in ICT services might seem at odds with the fact that some of the major companies that operate there (e.g. Google and Facebook) provide their services for free to users. However, they do charge for advertising space on their websites, and anecdotal evidence suggests that those prices show very strong increases given their increasingly dominant position in the online advertising market (The Economist, 2017).

3. We measure producer prices by industry-level gross output deflators.

4. These countries are: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Japan, Luxembourg, Latvia, Mexico, Netherlands, Norway, Poland, Portugal, Slovenia, Slovak Republic, Sweden, Switzerland and the United States. The country coverage is somewhat smaller in the mark-ups and policy analysis.

18. We confronted two main hurdles when constructing our combined analytical database, which came at considerable computational cost. First, in order to exploit the timeliest indicators of GVCs, we appended the TiVA Nowcast database (covering 2012-2014) to the industry-level GVC indicators that span 1995-2011 in the historical TiVA database. Second, we needed to address the industry classification mismatch between the TiVA data – which is measured with international classification system ISIC Rev.3 at the 2-digit level – and the 2017 release of the STAN database, which conforms to the ISIC Rev.4 classification. To this end, STAN data were converted to the equivalent ISIC Rev.3 industries using the generic concordance presented in Table A.1 in order to ensure alignment with the TiVA data.⁵

19. The TiVA Nowcast data use a slightly different process to the TiVA database. Rather than using a new inter-country input-output (ICIO) table as for a regular TiVA update, the Nowcast projections are based on the latest 2011 OECD ICIO table and use more recent national input-output industry tables, national accounts and bilateral trade data (OECD, 2017). Importantly, the Nowcast annual projections are made in volumes terms (to account for differential price movements and changes in exchange rates) which are then iteratively reflat and balanced using official volume and current price activity and trade data to ensure comparability. However, given the underlying ICIO tables are not fully updated, we cannot rule out that there may have been greater shifts in structure of the international production process which are not fully reflected in the TiVA Nowcast data.

3.1.1 GVC indicators

20. We examine several relevant GVC indicators motivated by the existing literature. Following Johnson and Noguera (2012), our primary variable of interest is the Backward Participation in GVCs indicator, defined as the foreign value added content of gross exports as a share of gross exports, at the country-industry level.⁶ This is an intensity measure ranging between 0 and 100 per cent, capturing global integration of the production process through the buying or sourcing internationally and the share of this foreign content embodied in a country's exports.⁷

21. Importantly, our baseline GVC indicator captures the indirect impact of foreign imported content through domestic value chains rather than the direct impact on final demand, differentiating it from standard import intensity measures. To illustrate this with an intuitive example, our baseline GVC intensity measure captures the role of value added embodied in the imported components of German cars coming from Eastern Europe but abstracts from German consumers purchasing Japanese cars on the German

5. Where multiple 2-digit industries in ISIC Rev.4 are combined in this process of conversion to ISIC Rev.3, aggregated production in volume terms or the price indices are calculated by applying the real growth rate for individual industries based on their time-varying nominal weights.

6. Auer et al (2017) also focus on this GVC variable in their recent analysis of inflation at the country level.

7. Given the assumptions of the TiVA database that exporters and domestic producers combine foreign output in the same proportion, this intensity measure is the same for domestic production as well as for exports. Put differently, a low export propensity of certain sectors (e.g. construction) still leaves our baseline measure relevant as it captures the intensity of backward global integration of that sector.

market (i.e. direct imports of final goods). We make this distinction in order to isolate the structural component of GVC integration, since alternate measures – such as the foreign value added embodied in domestic final demand or traditional measures of import penetration – are more likely to be directly affected by cyclical (domestic) demand factors and relative price shifts. For instance, an oil price increase can induce rising producer prices of the industries that are heavy users of imported oil, leading to a positive correlation between import penetration and inflation. This would make it more difficult to capture the structural, and potentially moderating, impact of higher GVC integration on inflation. Nevertheless, we also show results on the link between industry inflation and these alternative measures for completeness.

22. Moreover, since we are interested in the structural – or medium- to long-term – component of GVC integration, we take further steps (outlined in more detail in Section 4) to abstract from the influence of large relative price shifts. First, we always include country-year interacted fixed effects in our regressions to control for cyclical variations or exchange rate shocks. Second, we use a five-year long difference specification to filter out the impact of any short-run (e.g. year-to-year) changes in GVC intensities as well as prices. Finally, to further mitigate the role of large shifts in commodity prices during the crisis and its aftermath, we also estimate our baseline econometric specification using pre-crisis data only.

23. Finally, we exploit the bilateral trade block of the TiVA database to construct GVC indicators that take into account the source country of foreign value added content. More specifically, we create variables to proxy GVC integration with both “high-wage” and “low-wage” countries based on the level of economic development of the source country.⁸

3.1.2 Other variables

24. We also draw on a number of structural and policy variables to test the robustness of our baseline results. These include: *i*) a measure for ICT capital intensity, defined as the ratio of real ICT to non-ICT capital services, sourced from the latest EU KLEMS database (Jäger, 2017); *ii*) the stringency of employment protection legislation (EPL) of regular contracts (OECD, 2013), interacted with a sector-specific measure for EPL exposure, taken to be the layoff rate from the United States (Andrews and Cingano, 2014); and *iii*) the OECD regulatory burden indicator, which measures the knock-on effects of product market regulations in upstream sectors on downstream sectors via input-output linkages (Bourlès et al, 2013; Égert and Wanner, 2016).

25. When we explore how GVCs shape the propagation of the global economic cycle on industry-level inflation, we exploit annual data on output gaps (sourced from the November 2017 OECD *Economic Outlook* database) to estimate domestic and global economic slack for a particular country. Similar to the approach of Auer et al (2017) and Borio and Filardo (2007), we then combine bilateral industry-level GVC data from the OECD TiVA and TiVA Nowcast with these national output gap data to create a country-industry-year specific foreign output gap variable. More specifically, this is done by aggregating the output gap of each trading partner with a set of time-varying weights based on the partner’s share of the foreign value added (imported) content for a particular

8. The group of “high-wage countries” is chosen to be those that are part of the EU-15 (EU members prior to 2004) plus Australia, Canada, Japan, New Zealand, Norway, Switzerland and the United States, and “low-wage countries” are all other countries that are part of the TiVA database, including, among others, Asia and Eastern Europe.

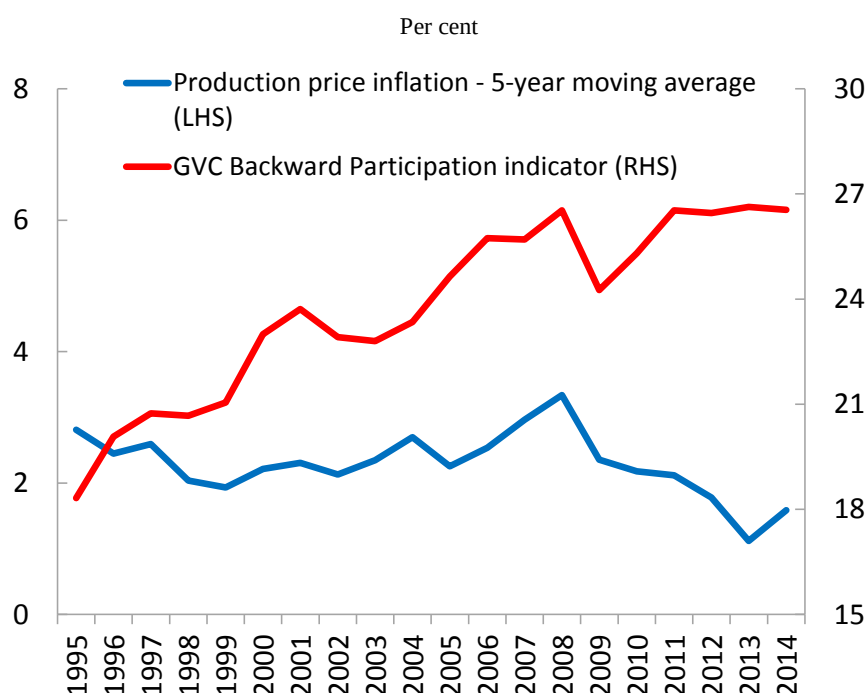
sector. In this manner, the weighting is consistent with our main variable of interest, the Backward Participation in GVCs indicator.⁹

26. Finally, to investigate the link between market power and industry-level price dynamics, we utilise cross-country longitudinal company-level data (Orbis) and a recent methodology that makes it possible to estimate firm- and time-varying mark-ups from firm-level financial information (De Loecker and Warzynski, 2012), as opposed to previous approaches that yield constant values over time or within sectors (Hall, 1986). Firm-level mark-ups are then aggregated to the sector level using revenue-based weights, to reflect the stronger influence of large firms. For a more detailed discussion see Box 1, Annex B and Andrews et al (2016).

3.2 Preliminary evidence on GVCs and inflation

27. The key summary statistics from our combined analytical database are contained in Table A.2. More instructively, the overall picture from our database supports the two main points discussed in Section 2. Figure 1 shows that on average across country-industry cells, GVC integration – as measured by the Backward Participation indicator – expanded significantly from the mid-1990s until the crisis, while inflation remained relatively subdued. In the post-crisis period, GVCs flattened off and remained around the pre-crisis peak, while producer price inflation has fallen dramatically and remains very low. However, these stylised facts are mere headline correlations, and more robust econometric framework (set out in Section 4) is required to control for the potentially confounding impact of unobservable shocks at the country, industry and year level.

Figure 1. Global value chains and inflation



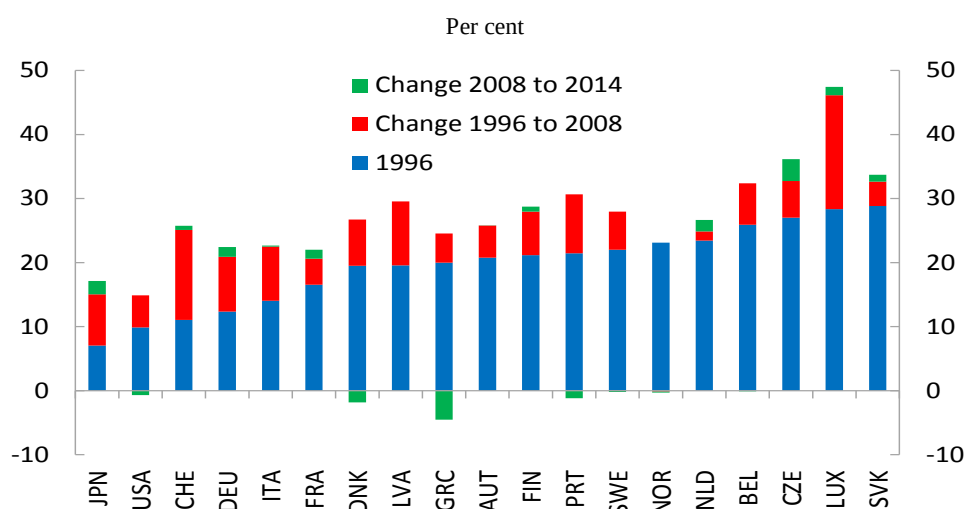
Note: Unweighted averages across all country-industry cells where data are available. Backward participation in GVCs is the foreign value added share of a sector's gross exports.

9. This covers the majority of the foreign value added content (greater than approximately 80 per cent in each year) for the countries in our sample.

Source: OECD STructural ANalysis (STAN) database; OECD Trade in Value-Added (TiVA) database; OECD TiVA Nowcast; and authors' calculations.

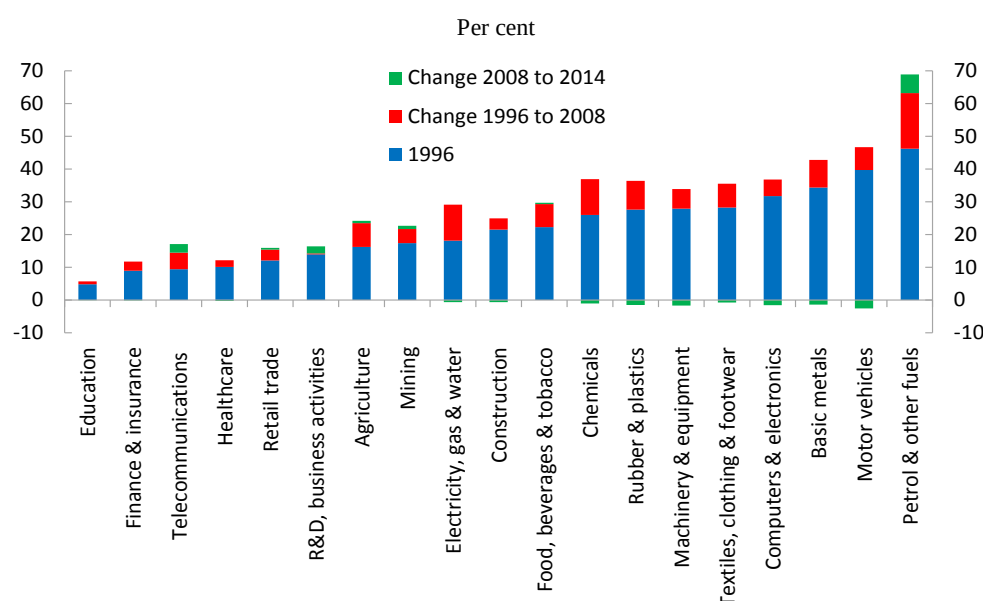
28. We observe a similar time series profile in GVC integration when looking within particular countries (Figure 2) and industries (Figure 3), although there are significant differences across countries and industries in the level of GVC participation. For example, large economies with significant internal markets, such as the United States, are characterised by lower GVC integration, whereas smaller European economies generally have the largest share of foreign value added in their own exports. Across industries, manufactured goods have much higher GVC participation than services sectors. Digging deeper into the time series profiles, among the major advanced economies, Germany and Japan have seen a significant percentage increase in their share of foreign value added inputs, while industries with a large percentage increase in GVC participation include, for example, the telecommunications and chemicals sectors.

Figure 2. Global Value Chain Backward Participation indicator by country



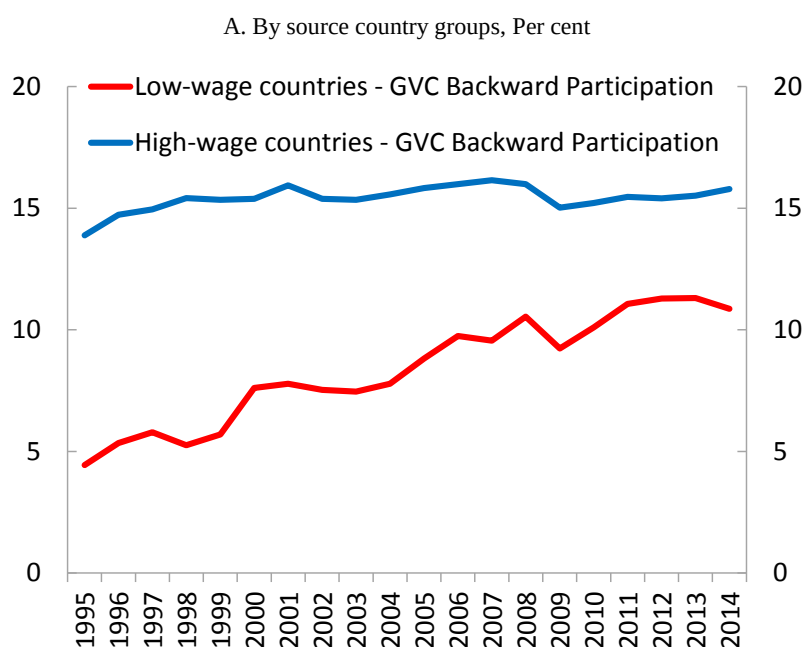
Note: Unweighted average across sectors in each country. Backward participation in GVCs is the foreign value added share of a sector's gross exports. For LVA, change for 2008 to 2014 is not available. 1996 data are not available for MEX, POL and SVN.

Source: OECD Trade in Value-Added (TiVA) database; OECD TiVA Nowcast; and authors' calculations.

Figure 3. Global Value Chain Backward Participation indicator by sector

Note: Unweighted average across countries in each sector. Backward participation in GVCs is the foreign value added share of a sector's gross exports. The figure shows a subset of industries out of the total 33 industries in our sample.

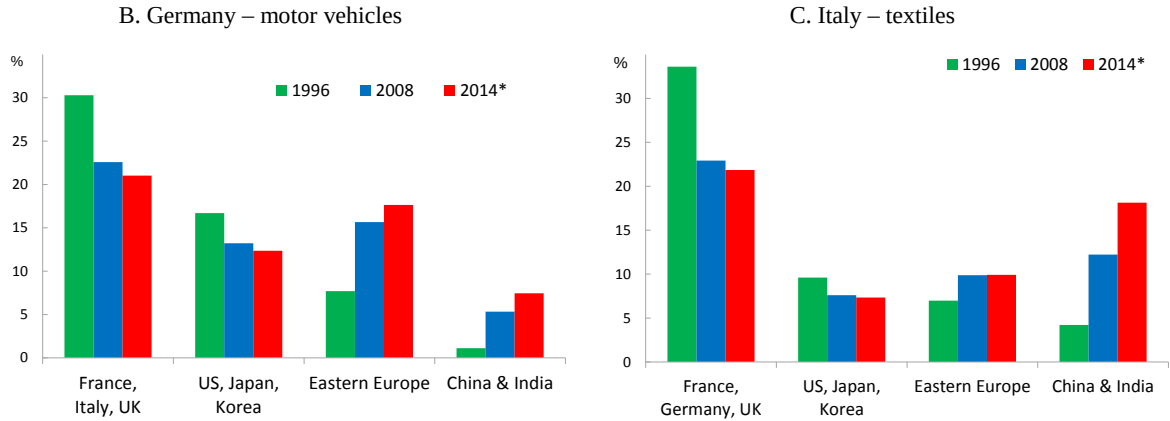
Source: OECD Trade in Value-Added (TiVA) database; OECD TiVA Nowcast; and authors' calculations.

Figure 4. Countries with lower wages have been contributing more to GVCs

Note: "High-wage countries" are those that are part of the EU-15 (EU members prior to 2004) plus Australia, Canada, Japan, New Zealand, Norway, Switzerland and the United States; "Low-wage countries" are all other countries in the TiVA database. Unweighted average across all country-industry cells where data are available. Backward participation in GVCs is the foreign value added share of a sector's gross exports.

Source: OECD Trade in Value-Added (TiVA) database; OECD TiVA Nowcast; and authors' calculations.

The composition of foreign value added by source country groups – two examples



Note: The category “Eastern Europe” in the figures contains the following countries: Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovak Republic, Slovenia and Russia. “Motor vehicles” is the industry “Motor vehicles, trailers and semi-trailers” (ISIC Rev.3 code 34) and “Textiles” is the industry “Textiles, textile products, leather and footwear” (ISIC Rev.3 codes 17, 18 and 19). 2014 are from the OECD TiVA Nowcast database hence it might not capture the full extent of changes in the structure of GVCs.

Source: OECD Trade in Value-Added (TiVA) database; OECD TiVA Nowcast; and authors’ calculations.

29. These aggregate data conceal an important shift in the composition of GVCs, with low-wage countries becoming increasingly integrated into global supply chains since the mid-1990s (Figure 4, Panel A). We also highlight two examples of this change in the country composition of foreign value added. Focusing on the motor vehicles industry in Germany, Figure 4 (Panel B) shows that Eastern Europe, China and India’s share of total imported foreign value added content in exports has increased by about 16 percentage points between 1995 and 2014. The corollary is a decrease in the reliance on more traditional trading partners, both within Europe (i.e. France, Italy and the United Kingdom), and further abroad (i.e. the United States, Japan and Korea). Panel C documents similar patterns in the Italian textile industry, with the increasing role of China and India particularly prominent. Importantly, this shift in the composition of GVCs toward low-wage countries continued from 2008, which potentially implies further disinflationary impacts of GVCs, even if the aggregate indicator has remained largely unchanged after then (Figure 1). It also appears that there is still much scope for OECD countries to further integrate low-wage countries into their supply chains, despite tentative signs of a slowing rise in low-wage country GVC participation in recent years (covered by the TiVA Nowcast data). However, further integration is not inevitable given rising protectionist pressures in the global economy.

4. Econometric framework

4.1 Baseline model

30. To more rigorously explore the link between inflation and global value chain integration, we estimate the following long difference specification:

$$\Delta^{ld}Y_{c,s,t} = \beta_0 + \beta_1 \Delta^{ld}GVC_{c,s,t} + \sum_j \gamma_j \Delta^{ld}X_{c,s,t}^j + \delta_{c,t} + \delta_s + \varepsilon_{c,s,t} \quad \text{Equation 1}$$

where: Δ^{ld} denotes the long difference operator, corresponding to five years in the baseline specification¹⁰; $Y_{c,s,t}$ denotes producer prices in the baseline estimation; $GVC_{c,s,t}$ the GVC Backward Participation indicator, where all variables are measured in log terms; and when appropriate, we include control variables (contained in the vector $X_{c,s,t}^j$) in long differences such as ICT intensity and product and labour market regulations, etc. We rely on an overlapping five-year long difference specification (e.g. 2014-2009, 2013-2008, etc.) to reduce the influence of short-term fluctuations and since the true structural component of the GVC indicator only varies at around five-year intervals (coinciding with the update of the inter-country input-output tables). Given that we cluster robust standard errors at the country-industry pair level, this choice of an overlapping five-year difference specification is innocuous (Bloom et al, 2015).

31. The baseline model includes interacted country-year fixed effects ($\delta_{c,t}$) to control for omitted time-varying country-specific shocks (e.g. macroeconomic shocks, exchange rate fluctuations, macroeconomic and structural policy changes) and industry fixed effects (δ_s) to control for time-invariant industry factors (e.g. technological differences in market structure). This choice of fixed effects structure implies that we are identifying off within-industry changes in GVC participation once we have purged the data of time-varying aggregate shocks.

32. While this arguably leads to cleaner identification, it may also mean that we abstract from certain macro-level channels through which GVC integration affects inflation, implying that our estimates can be considered a lower-bound. For example, our country-year fixed effects could absorb any moderating influence on wage growth – and by implication, inflation – that may arise from a general perception among workers that they face ever greater competition from foreign labour. In a similar vein, our coefficient estimates will abstract from the potential for higher GVC integration to reduce inflation expectations over the long-run. As noted earlier, technological advances – especially digitalisation – have enabled the expansion of GVCs so we are not solely picking up the effect of globalisation on inflation and wages. For completeness, we also run specifications including industry-year fixed effects ($\delta_{s,t}$) to control for omitted time-varying sector-specific shocks (e.g. global commodity price cycles, sector-specific technology shocks) and country-industry fixed effects ($\delta_{c,s}$) to control for time-invariant country-industry specific factors.

33. Finally, our main parameter of interest is β_1 . If the dependent variable (Y) is producer prices (as in our baseline specification) and $\beta_1 < 0$, for example, then an expansion of GVC integration – i.e. so imported inputs are used more intensively in a given country's exports – is associated with lower inflationary pressure.

4.2 Channels and other extensions

34. To better understand the channels through which GVC integration is linked to industry inflation, we undertake a number of further econometric exercises. First, we run a series of regressions where the dependent variable in Equation 1 pertains to unit labour costs, wages or labour productivity. Due to the strong interrelation among these outcome variables, we take the evidence derived from these steps as merely suggestive, acknowledging that a more complete analysis would require alternative, more structural

10. The results are not particularly sensitive to the choice of the length of the long difference window.

estimation approaches. Second, we explore the extent to which our baseline results are driven by GVC integration with low-wage countries using the indicators described in Section 3.

35. Third, we investigate the propagation of shocks through GVC integration via domestic and global economic slack through Equation 2 and Equation 3 below. As described in Section 3, global slack is measured by the country-industry-time specific foreign output gap variable $ForGap_{c,s,t}$, building on Auer et al (2017) and Borio and Filardo (2007) and adapting it to the industry level. We first rely on continuous variation in the output gap variables (Equation 2). Our working hypothesis is $\delta_3 > 0$; that is for higher GVC integration, a more negative foreign output gap will put greater downward pressure on inflation. This would indicate that global slack is more important for domestic price changes with high GVC participation. We then test for potential asymmetries by defining a dummy variable pertaining to “foreign slack” when foreign output is below potential (i.e. there is a negative foreign output gap; Equation 3). Our hypothesis is that foreign sources are used more heavily when there is slack in those source country-sectors, captured by $\delta_5 < 0$.

$$\Delta P_{c,s,t} = \delta_0 + \delta_1 GVC_{c,s,t} + \delta_2 ForGap_{c,s,t} + \delta_3 ForGap_{c,s,t} * GVC_{c,s,t} + \delta_4 DomGap_{c,t} * GVC_{c,s,t} + \delta_{c,t} + \delta_s + \varepsilon_{c,s,t} \quad \text{Equation 2}$$

$$\Delta P_{c,s,t} = \delta_0 + \delta_1 GVC_{c,s,t} + \delta_2 ForGap_{c,s,t} + \delta_3 ForGap_{c,s,t} * GVC_{c,s,t} + \delta_4 ForSlack_{c,s,t} + \delta_5 ForSlack_{c,s,t} * GVC_{c,s,t} + \delta_6 DomGap_{c,t} * GVC_{c,s,t} + \delta_{c,t} + \delta_s + \varepsilon_{c,s,t} \quad \text{Equation 3}$$

36. This specification relates the (log) change in producer prices to the (log) level of GVCs and interactions of GVCs with the country-time specific domestic output gap and country-industry-time specific foreign output gap. In this exercise, we exploit the annual variation in domestic and foreign output gaps and over the course of the business cycle to explore how the level of GVC integration shapes the propagation of foreign – relative to domestic – slack onto domestic producer price inflation. As in the baseline model, the fixed effects structure controls for unobserved time-varying country-specific shocks ($\delta_{c,t}$) and time-invariant industry (δ_s) factors.¹¹ Finally, robust standard errors are clustered at the country-industry level.

37. Finally, in Section 6 where we investigate the link between market power and industry-level price dynamics, we utilise a variant of the long-difference specification in Equation 1 for comparability purposes, but with a mark-up term in place of the GVC term.

5. Empirical results

5.1 Baseline results

38. Table 1 shows the baseline estimates for the five-year long difference specification (Equation 1) for producer prices. Regardless of the fixed effects structure –

11. Note that the separate domestic output gap term is absorbed by the country-year fixed effects.

which becomes increasingly burdensome as we move across columns – the change in the industry producer prices is negatively related to the change in GVCs and the coefficient is statistically significant at the 1% level. This suggests that within industries, increasing integration in GVCs has been associated with lower producer price inflation over the sample period.

39. The negative relationship between the change in GVCs and producer prices uncovered in Table 1 is robust to a number of tests.

- First, we re-estimate the model on pre-crisis data only to further control for the impact of large shocks (Annex A, Table A.3).¹²
- Second, we use price changes one year ahead as the dependent variable to capture a potential delay in the effect of changes in GVCs on industry prices (Table A.4).
- Third, we control for within-country industry-level variation in product market regulations, employment protection legislation and the ICT capital share to address the concern that our baseline estimates are simply picking up structural reform or the role of technology (Table A.5). However, it should be acknowledged that the ICT capital share is a relatively crude and limited measure of technological change but exploring this issue further is outside the scope of this paper.
- Fourth, the GVC term remains negative and significant when we control for the traditional trade openness measures such as change in the import share of production (Table A.6). Indeed, once the role of GVCs is taken into account, we find that such conventional measures of trade openness have limited power in explaining the structural link between globalisation and domestic producer price inflation, consistent with Auer et al's (2017) findings based on aggregate data.¹³
- Finally, the negative relationship between GVC integration and prices is robust to using alternative measures of GVC integration such as foreign value added embodied in domestic final demand (Table A.7). Of course, these measures are more likely to be directly affected by cyclical demand factors and relative price shifts than our baseline backward participation in GVCs indicator, as domestic demand shocks for foreign final goods lead to a positive correlation between industry output prices and these types of final demand-based GVC measures (see Section 3).¹⁴

12. The baseline results are also robust to excluding very small globally-integrated economies, such as Luxembourg and Switzerland.

13. This could be driven by the stronger sensitivity of this measure to commodity price shocks, which in turn can induce a positive correlation between industry output prices and import intensity (e.g. imported oil price increases leading to price hikes in automotive fuel).

14. Again, this could explain why their negative coefficients are less pronounced than those for our baseline GVC measure.

Table 1. Prices and global value chains

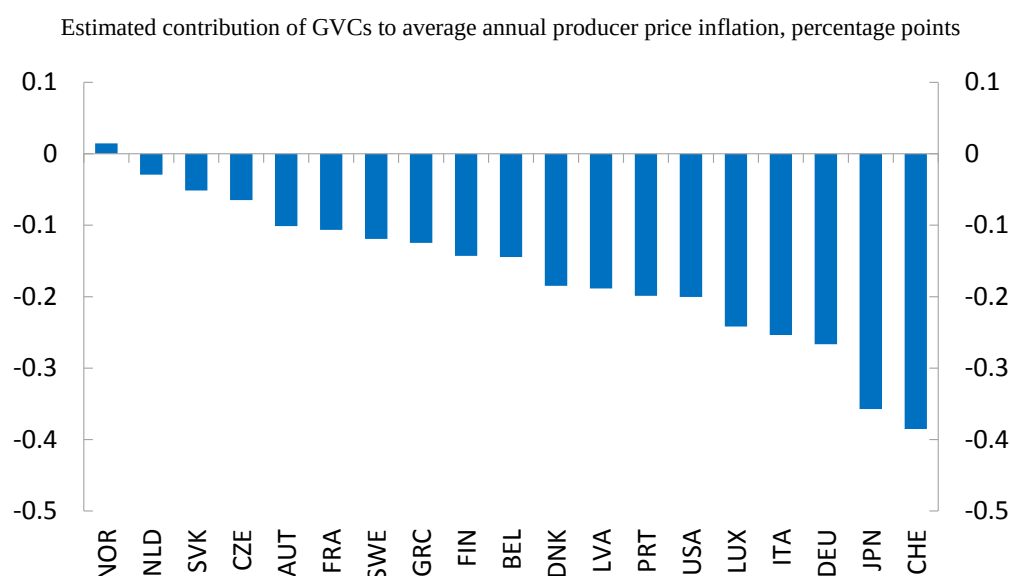
Estimation method – five-year long differences

	$\Delta P_{c,s,t}$		
	(1)	(2)	(3)
$\Delta GVC_{c,s,t}$	-0.0574*** (0.0148)	-0.0540*** (0.0165)	-0.0460*** (0.0173)
Country*Year fixed effects	YES	YES	YES
Industry fixed effects	YES	NO	NO
Industry*Year fixed effects	NO	YES	YES
Country*Industry fixed effects	NO	NO	YES
Observations	8,492	8,492	8,492
Adj R-squared	0.578	0.645	0.802

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The price level and GVC indicator are measured in log terms. The time period is in principal 1995-2014. See more details in the text.

40. Figure 5 performs a counterfactual simulation to estimate how much producer price inflation would have fallen due to the observed rise in GVC participation from 1996 and 2008, relative to a situation where GVC participation remained at 1996 levels.¹⁵ On average across countries, annual producer price inflation is estimated to have been 0.15 percentage points lower on average over 1996-2008 due to the rise in GVCs, during which annual producer price inflation averaged 2.5 per cent. In Germany – where the level of GVC integration almost doubled (Figure 2 in Section 3) – annual producer price inflation was on average 0.25 percentage points lower under this counterfactual exercise. This figure conceals considerable variation across industries within Germany, however, with the disinflationary impulse equivalent to around 0.6 percentage points in the telecommunications industry (where GVC participation increased by more than threefold) and 0.2 percentage points in the motor vehicles industry (where GVC participation increased by 50 per cent).

¹⁵ The assumption behind this ceteris paribus counterfactual simulation is that the increase in GVC participation in certain sectors did not affect producer prices in sectors where GVCs remained constant. Consistent with this is the assumption that monetary policy is held constant (i.e. would not have reacted differently), thus allowing for average producer price inflation to change.

Figure 5. Impact of GVC expansion on inflation over 1996-2008

Note: The figure shows the annual change in producer price inflation based on the change in the production deflator that is explained by rising GVCs using the coefficient estimate in column 1 of Table 1. The estimates are the unweighted averages over industries in each country from 1996 to 2008. MEX, POL and SVN not shown as data on GVCs are not available for 1996.

Source: Calculations using estimation results from Table 1 and the OECD Trade in Value-Added (TiVA) database

5.2 GVCs and wages

41. Stronger integration into GVCs can lead to lower domestic prices via several channels (see Section 2). It can put downward pressure on wage growth through the use of foreign workers embodied in inputs who thus become more direct competitors to domestic workers. Moreover, a wider pool of foreign suppliers enables domestic firms to access better quality and/or cheaper imported inputs which may further decrease output prices.¹⁶ Stronger GVC integration can also raise productivity, which together with lower wages reduces unit labour costs. While an exact decomposition of these channels would require a more structural approach – since wages and productivity are interrelated – we take some exploratory steps to shed light on these issues using our econometric framework. Accordingly, Table 2 shows the baseline estimates for the five-year long difference specification (Equation 1) for unit labour costs by sector with the similar fixed effects structure. In each case, the change in the industry unit labour costs is negatively related to the change in GVCs and the coefficient is statistically significant at the 1% level.

42. In the spirit of Figure 4, we then dig deeper and further explore how prices, wages and labour productivity in advanced economies are shaped by backward GVC integration with “high-wage” and “low-wage” countries. Table 3 shows the estimates for the baseline five-year long difference specification. Column 1 shows that the change in the industry producer prices is negatively related to the change in both GVC variables, but only for GVCs with low-wage countries is the coefficient statistically significant. This indicates

16. The strength of this channel can be affected by wage setting institutions, in particular the nature of collective bargaining, which is outside the scope of this paper.

that GVC integration with low-wage countries is especially disinflationary. Focusing on industry real wages (column 2) yields similar results with the coefficient on the low-wage countries GVC term negative and statistically significant when controlling for labour productivity (which is strongly correlated with real wages).¹⁷ This is consistent with the idea that GVCs in advanced economies exert a stronger downward pressure on domestic wages due to the threat of using foreign suppliers (outsourcing). Column 3 shows that for the change in industry labour productivity – for both GVCs with high-wage and low-wage countries – the coefficient is positive and statistically significant. This implies that industries with greater GVC integration either with high-wage or with low-wage countries are both associated with larger increases in labour productivity.

Table 2. Unit labour costs and global value chains

Estimation method – five-year long differences

	Δ Unit labour costs _{c,s,t}		
	(1)	(2)	(3)
Δ GVC _{c,s,t}	-0.231*** (0.0378)	-0.215*** (0.0406)	-0.192*** (0.0392)
Country*Year fixed effects	YES	YES	YES
Industry fixed effects	YES	NO	NO
Industry*Year fixed effects	NO	YES	YES
Country*Industry fixed effects	NO	NO	YES
Observations	8,122	8,122	8,122
Adj R-squared	0.362	0.379	0.527

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Both unit labour costs and the GVC indicator are measured in log terms. Unit labour costs are measured as compensation of employees divided by real output. The time period is in principal 1995-2014.

17. The significant impact of GVCs on labour productivity and the strong relationship between wages and productivity motivates including labour productivity in the wage equation as a control variable. Doing so reveals that there is a separate, additional effect of GVC integration on wages, beyond the indirect impact through productivity.

Table 3. Prices, wages and labour productivity in advanced economies by source country

Estimation method – five-year long differences

	$\Delta P_{c,s,t}$	$\Delta W_{c,s,t}$	$\Delta \text{Labour Productivity}_{c,s,t}$
	(1)	(2)	(3)
$\Delta \text{GVC}_{c,s,t}$ (Low-wage countries)	-0.0368*** (0.0131)	-0.0254* (0.0151)	0.0994*** (0.0351)
$\Delta \text{GVC}_{c,s,t}$ (High-wage countries)	-0.0166 (0.0152)	-0.0216 (0.0216)	0.117*** (0.0324)
Controlling for labour productivity	NO	YES	n/a
Country*Year fixed effects	YES	YES	YES
Industry fixed effects	YES	YES	YES
Observations	6,172	6,172	6,172
Adj R-squared	0.527	0.409	0.332

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All indicators are measured in log terms. Subset of our full sample restricted to advanced economies (AUT, BEL, CHE, DEU, DNK, FIN, FRA, GRC, ITA, JPN, LUX, NLD, NOR, PRT, SWE and USA). GVCs (High-wage countries) is the foreign value added share in exports of those countries that are part of the EU-15 (EU members prior to 2004) plus AUS, CAN, CHE, JPN, NOR, NZL and USA; GVCs (Low-wage countries) is the foreign value added share in exports of all other countries. Real wages are measured as nominal wages and salaries per employee deflated by the economy-wide production deflator. Labour productivity (output per worker) is the volume of production per employee. The time period is in principal 1995-2014.

5.3 Propagation of shocks: GVCs and the global economic cycle

43. Finally, we explore how the level of GVC participation shapes the propagation of slack in foreign product and labour markets on domestic inflation. Table 4 (column 1) shows the estimates for Equation 2 of industry producer price changes and GVC integration via foreign and domestic output gaps including country-year fixed effects and separate industry fixed effects. Column 2 adds country-industry fixed effects. In both specifications, the change in the industry producer prices is positively related to the interaction between the foreign output gap and the GVC indicator, and the coefficient is statistically significant at the 1% level. Again, the coefficient estimates are robust to restricting the sample to the pre-crisis period and to using alternative measures of GVC integration with the foreign value added embodied in domestic final demand (Table A.8).

44. Table 4 (columns 3 and 4) also shows the estimates for Equation 3, which includes a dummy variable for foreign slack (when the foreign output gap variable is negative, indicating that activity in a country's source markets are currently below potential output). We find that the presence of foreign slack puts downward pressure on producer prices and that GVCs affect the propagation of shocks via foreign slack from the additional interaction term. This indicates that GVC integration creates an option for firms to exploit cheaper intermediates abroad, and that they exercise this option when it makes sense to do so – i.e. when there is slack in foreign product and labour markets, as

opposed to tightness.¹⁸ Taken together, these results imply that weak global demand (as indicated by large negative foreign output gaps) has a larger disinflationary impact when GVC participation is higher.

Table 4. Inflation, global slack and global value chains

Estimation method – annual				
	$\Delta P_{c,s,t}$			
	(1)	(2)	(3)	(4)
GVC _{c,s,t}	-0.00090 (0.00314)	-0.00002 (0.00628)	0.00290 (0.00418)	0.00280 (0.00420)
Foreign YGap	0.00327 (0.00233)	0.00345 (0.00237)	0.00253 (0.00249)	0.00234 (0.00250)
Foreign YGap*GVC _{c,s,t}	0.00468*** (0.00085)	0.00468*** (0.00088)	0.00283*** (0.00080)	0.00312*** (0.00089)
Foreign Slack			-0.00729* (0.00374)	-0.00729* (0.00374)
Foreign Slack*GVC _{c,s,t}			-0.00681** (0.00340)	-0.00683** (0.00340)
Domestic YGap*GVC _{c,s,t}	-0.00024 (0.00034)	-0.00028 (0.00036)		-0.00025 (0.00033)
Country*Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	NO	YES	YES
Country*Industry fixed effects	NO	YES	NO	NO
Observations	11,026	11,026	11,026	11,026
Adj R-squared	0.248	0.249	0.249	0.249

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. YGap measured as per cent of a country's estimated potential output. YGap < 0 (or >0) for an economy that is below (or above) potential output. Foreign Slack = 1 when Foreign YGap<0 and Foreign Tight = 1 when Foreign YGap≥0. Industry producer price inflation is the annual change in the log of the industry production deflator. GVC indicator measured in log terms and demeaned by the sample average. The time period is in principal 1995-2014.

45. Figure 6 performs a counterfactual simulation which estimates how much lower inflation would be as a result of the expansion of GVCs and negative foreign output gaps for each country at the end of our sample period in 2014 (when the average foreign output gap was -1.5 per cent) since 1996.¹⁹ This exercise suggests that, on average across our sample countries, annual producer price inflation was 0.25 percentage points lower in

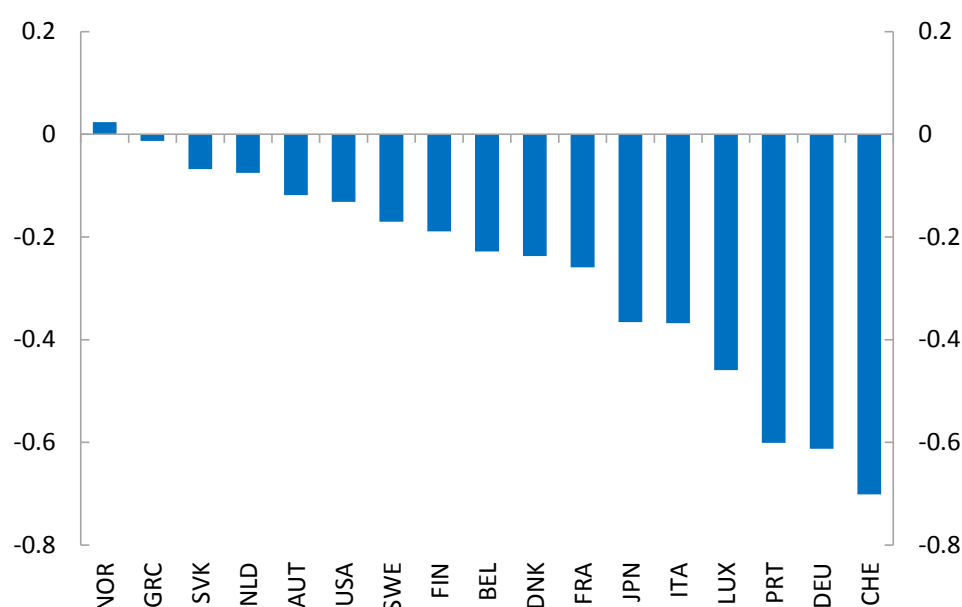
18. Including a further variable and interaction term to examine variation in the *magnitude* of the negative foreign output gap and its interaction with GVCs indicates that, in addition to the effect of the foreign output gap and foreign slack dummy variables, the magnitude of the negative foreign output gap is not significant.

19. This ceteris paribus simulation rests on the same assumptions as described at the end of Section 5.1.

2014 due to the rise in GVCs from 1996 to 2014.²⁰ The negative impact on inflation is larger for those countries with a greater increase in the level of GVC participation and/or facing a larger foreign output gap in 2014. For instance, given a foreign output gap of -2 per cent, producer price inflation in Germany is estimated to be 0.6 percentage points lower in 2014 due to the actual rise in GVC integration, relative to a counterfactual where GVCs remained at 1996 levels. These results are significant because even though GVC integration stopped rising after 2008, the higher level of GVC integration today still dampens inflation by accentuating the impact of global economic slack, consistent with the findings of Auer et al (2017).

Figure 6. Impact on inflation in 2014 due to global slack and the expansion of GVCs since 1996

Estimated contribution of foreign slack through greater GVCs to producer price inflation in 2014, percentage points



Note: The figure shows the annual change in producer price inflation in 2014 that is explained by the change in the level of GVCs since 1996 and the interaction of GVCs with the foreign and domestic output gaps, based on the coefficient estimates in column 1 of Table 4. The GVC estimates are the unweighted averages over industries in each country for 1996 and 2014. MEX, LVA, POL and SVN not shown as data on GVCs are not available for 1996 or 2014.

Source: Calculations using estimation results from Table 4, the OECD Trade in Value-Added (TiVA) database and OECD TiVA Nowcast.

6. Future risks: will weakening competition let the inflation genie loose?

46. Researchers in the early 2000s identified more intense competition in product markets and enhanced flexibility in labour markets as key factors behind global disinflation, but there is emerging evidence that product markets have been becoming less

20. We are using the same country-specific 2014 foreign output gaps (unweighted average across sectors).

contestable (Section 2). Consistent with these developments, the market power of firms seems to be on the rise in the United States (De Loecker and Eeckhout, 2017) and other OECD countries (Calligaris et al, 2018), as suggested by an upward trend in mark-ups. This could be driven by advances in technology that allow firms to improve quality and achieve higher margins, on the one hand, or, perhaps simultaneously, to create and preserve abusive market power, on the other hand.²¹ We investigate the consequences of rising mark-ups for inflation (a complete analysis of the drivers behind mark-up trends is outside the scope of this paper). Indeed, a key issue is the extent to which rising market power could translate into inflationary pressures building up in the medium term and risk letting the inflation genie out of the bottle.

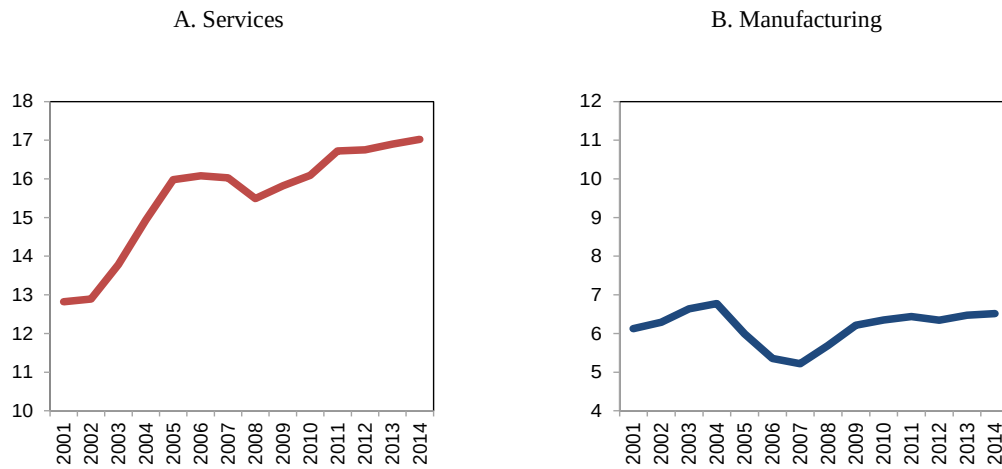
47. To investigate the link between mark-ups and inflation, we utilise a rich cross-country firm-level database (Orbis, see Box 1 for details).²² Consistent with previous research, we find that mark-ups are rising in the market services sector (Figure 7) and firm-level econometric evidence suggests that this increase is statistically significant (Box 1). Not only do services mark-ups experience a rising trend, they also exhibit higher *levels* than in manufacturing. Given that services account for an increasing share of activity as well as the consumer basket, these findings can pose upside risks to future inflation developments.

21. Moreover, currently available data (e.g. lack of firm level output prices) and methodology do not allow for distinguishing between quality improvement driven or market power driven increases in mark-ups.

22. In the analysis below, country and sector coverage is limited to the availability of appropriate firm-level data. Accordingly, the following countries are included: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, Luxembourg, Latvia, Netherlands, Portugal, Sweden and the United States. The financial and the public sectors are excluded from the analysis. See more details in Section 3 and in Annex B.

Figure 7. Mark-ups are on the rise in services

Estimated firm-level mark-ups averaged across broad sectors and countries, percentage points



Note: The figure shows the 3-year moving average of size-weighted mark-ups aggregate to the 2-digit sector for each country and year, and then averaged across them by two sector-groups, manufacturing and non-financial business services. For the construction of this figure, only those country-industry cells are retained for which the average number of observations per year is at least 20 and where the number of firms over time is relatively stable (top quartile is not more than three times the bottom quartile). For more details, see Section 3 and Annex B.

Source: Calculations using the Orbis database of Bureau van Dijk.

Box 1. Firm-level mark-ups: measurement and trends over time

To test whether the rising trend in mark-ups in Figure 7 is statistically significant, the following regressions are estimated on cross-country firm level data over the period 2001-2014:

$$Markup_{i,t} = \beta_0 + \beta_1 Trend_t [+ \beta_2 D_s Trend_t] + \delta_{c,s} + \varepsilon_{i,t}$$

where mark-ups are measured at the firm (*i*) and year (*t*) level (in logs * 100, see details in Annex B), $\delta_{c,s}$ indicate country-industry fixed effects and the *Trend* variable captures the average annual change in mark-ups (Table 5). We also test whether the trend is significantly different across sectors by interacting the trend with a dummy variable denoting services (columns 2 and 4). Finally, we repeat all these specifications when weighting with firm size – measured by output – to take account of the more important role of larger firms on overall market power.

The results confirm the statistical significance of the patterns shown in Figure 7: mark-ups have an increasing trend, overall by 0.18 percentage points per year (column 1). This upward trend is much stronger in and is driven by services (0.4 percentage points, column 2), and additional analysis shows that the upward trend is particularly pronounced in ICT-intensive services, consistent with the findings of Calligaris et al (2018). The size-weighted regression show smaller trend increases, while the nature of differences across sectors is similar (columns 3-4).

Table 5. Mark-ups are trending upward, driven by services

	Firm-level mark-up _{c,s,t}			
	(1)	(2)	(3)	(4)
Time trend	0.181*** (0.0404)		0.0181 (0.0548)	
Time trend (Manufacturing)		-0.0334 (0.0633)		-0.0839 (0.0506)
Time trend (Additional trend in services)		0.389*** (0.0568)		0.231** (0.0889)
Country*industry fixed effects	YES	YES	YES	YES
Size-weighted	NO	NO	YES	YES
Observations	1,308,585	1,125,237	1,308,585	1,125,237
Adj R-squared	0.516	0.508	0.692	0.675

Note: Mark-ups are measured in logs times 100, thus the interpretation of the trend coefficient is the annual change in the mark-up in percentage points. Size-weighting uses output weights (where outputs are measured by revenues). Columns 2 and 4 compare manufacturing and non-financial business services, excluding other industries (construction, mining, etc.). The time period is in principal 2001-2014. The standard errors are clustered at the year level, while results are robust to country-industry level clustering. For more details on the data preparation see Annex B.

48. Motivated by standard macroeconomic models that link prices to mark-ups, we apply the econometric methodology described in Section 3 to estimate the relationship between prices and mark-ups. Our results show a positive and statistically significant relationship in business services sectors over the sample period (Table 6). While the sample size is substantially lower than in baseline analysis, this finding is still robust to the inclusion of GVCs and wages (Table 6; columns 2-4).²³

49. The economic magnitude of the impact of mark-ups on inflation varies significantly across industries and countries. Typically the ICT-intensive services show the strongest increase in mark-ups, in line with the findings of Calligaris et al (2018). For instance, the ICT services sector in the Nordic countries in our sample (Denmark, Finland and Sweden) have experienced a rise of up to 5 percentage points per year in the mark-up in the early 2000s. According to our coefficient estimates (Table 6; column 1), this implies that industry inflation is about 0.2 percentage points higher per annum, relative to a counterfactual where mark-ups remained constant. This within-industry effect is likely to understate the total effect on inflation, however, to the extent that ICT services serve as an intermediate input in downstream sectors (see Bourlès et al, 2013 for more details). At the other extreme, sectors that have undergone liberalisation in entry in many OECD countries typically show declines or smaller increases in mark-ups (i.e. transport, telecommunications and retail trade). Thus, policy efforts to adapt pro-competitive market regulations to the digital age will not only bring benefits to long-run productivity growth but will also be desirable from a monetary policy perspective.

Table 6. Prices and mark-ups are positively related in services

Estimation method – five-year long differences

	$\Delta P_{c,s,t}$			
	(1)	(2)	(3)	(4)
$\Delta \text{Mark-up}_{c,s,t}$	0.0403** (0.0163)	0.0375** (0.0174)	0.0419** (0.0179)	0.0427** (0.0196)
Country*Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
Controls	None	Wages	GVCs	Wages, GVCs
Observations	979	928	973	922
Adj R-squared	0.651	0.647	0.649	0.647

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The price level and mark-ups are measured in log terms. The time period is in principal 1995-2014 and the sectoral coverage is the non-financial business services.

7. Conclusion and future research

50. This paper explores the impact of GVC participation and competition on inflation by drawing together a range of recent industry-level and micro-data sources. We provide evidence that rising integration in GVCs has placed downward pressure on domestic

23. This reflects the more limited availability of microdata and the restriction to services sector.

producer prices at the industry level. Controlling for a range of time-varying country-specific and global shocks, we estimate that the rise in GVCs – at its peak – reduced annual producer price inflation by 0.15 percentage points on average, but this effect is more than double in some OECD countries. We also find that rising GVC integration within industries is associated with lower unit labour costs and wages. The impacts on prices and wages are especially strong when low-wage countries are more intensively integrated in supply chains, implying that further shifts in the composition of GVCs toward low-wage countries could continue to dampen inflation. Taken together, our analysis supports the conjecture that GVC expansion – facilitated by not only trade liberalisation but also technological advances – has increased the ability of firms to substitute domestic inputs with cheaper foreign equivalents, thereby putting downward pressure on prices.

51. We also present industry-level evidence in support of the notion that higher GVC integration reduces inflation via the propagation of global economic slack, in the spirit of Auer et al's (2017) recent analysis based on aggregate data. Given an average foreign output gap of -1.5 per cent in 2014, we estimate that annual producer price inflation was on average 0.25 percentage points lower in 2014 due to the actual rise in GVC integration from 1996 levels. But this effect rises above 0.5 percentage points for countries that experienced a particularly large rise in GVC participation over this period.

52. Looking forward, there is a risk that stalling globalisation coupled with declining market contestability – particularly rising market power – could lead to inflationary pressures over the medium term, thus letting the inflation genie out of the bottle. We use cross-country micro data to provide evidence that mark-ups in market services sectors in OECD countries have risen significantly since the early 2000s. We then demonstrate a robust positive correlation between producer price inflation and mark-ups within industries. Moreover, if more intense competition in product and labour markets contributed to global disinflation in over recent decades (Rogoff, 2003), then it follows that waning structural reform ambition – against the backdrop of strengthening aggregate demand – poses an upside risk to future inflation.

53. Several issues need to be kept in mind when considering the implications of these results for monetary policy. First, our focus is on the cost-related impacts of foreign sourcing through GVCs for domestic producers, hence our dependent variable is sector-level producer price inflation. In contrast, monetary policy focuses on consumer price inflation which is influenced by other factors that can affect the pass-through from changes in producer prices. Second, our empirical approach identifies the impacts on deviations from country-year averages to exclude the influence of unobserved time-varying country-specific factors, i.e. shocks that affect aggregate producer price inflation. Put simply, we identify impacts on relative price changes within countries and across sectors. Negative relative price pressures due to increased GVC participation can be considered positive supply shocks, hence may not require a monetary policy response (Friedman, 1975). On the other hand, a combination of asymmetric price changes and the presence of price adjustment costs can, in some cases, still affect equilibrium inflation and optimal monetary policy (Ball and Mankiw, 1995; Auer and Fischer, 2010). Also, consumer price inflation and producer price inflation may be diverging due to the expansion of GVCs (Wei and Xie, 2018), which can impact optimal monetary policy (Huang and Liu, 2005; Strum, 2009). Overall, how monetary policy should respond in this context of a prolonged positive supply shock is outside the scope of this paper.

54. A number of areas emerge for future research. First, while we exploit the best currently available GVC measures and use a rich set of fixed effects in our regression analysis, the GVC indicators could be adjusted and extended to ensure further robustness. For example, the impact of commodity price movements on industry-level producer price inflation could be partially controlled for by exploiting the bilateral GVC data combined with industry-level price data in the source countries. More comprehensively, the OECD's TiVA Nowcast draws upon estimates of production in volume terms which may be included in future full TiVA releases and could help mitigate the impact of different price movements on production estimates at the industry level within countries. Also, investigating the effect of GVC integration via the foreign goods versus the foreign services content of gross exports would be interesting. Second, while we focus solely on producer price inflation, future work could analyse the implications of GVC integration and market power for consumer price inflation. Third, it would be interesting to explore how cross-country differences in institutional and structural factors – i.e. the extent of worker bargaining power, the degree of competitive pressures, etc. – shape the pass-through of GVC integration to industry inflation.

55. From a policy perspective, a deeper understanding of dynamics of the market services sectors appears to be crucial. The observed rise in mark-ups is particularly significant in ICT-intensive services, which indicates policy efforts to adapt pro-competitive market regulations to the digital age may yield benefits for long-run productivity growth as well as from a monetary policy perspective. More speculatively, it may be possible that in certain sectors the combination of GVCs and digitalisation could raise market power via network effects, but this remains for further investigation. Finally, greater research on the impact of deeper GVC integration and the role of trade barriers in services sectors may yield benefits for understanding drivers of greater market competition with gains for productivity growth, both in services and related industries.

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Annex A.

Table A.1. ISIC Rev.4 to ISIC Rev.3 industry concordance table

Industry	ISIC Rev.3	ISIC Rev.4
Agriculture, hunting, forestry and fishing	01t05	01t03
Mining and quarrying	10t14	05t09
Food products, beverages and tobacco	15t16	10t12
Textiles, textile products, leather and footwear	17t19	13t15
Wood and products of wood and cork	20	16
Pulp, paper, paper products, printing and publishing	21t22	17, 18, 58
Coke, refined petroleum products and nuclear fuel	23	19
Chemicals and chemical products	24	20t21
Rubber and plastics products	25	22
Other non-metallic mineral products	26	23
Basic metals	27	24
Fabricated metal products except machinery and equipment	28	25
Machinery and equipment n.e.c	29	28
Computer, electronic and optical products	30, 32, 33	26
Electrical machinery and apparatus n.e.c	31	27
Motor vehicles, trailers and semi-trailers	34	29
Other transport equipment	35	30
Manufacturing n.e.c; recycling	36t37	31t33
Electricity, gas and water supply	40t41	35, 36
Construction	45	41t43
Wholesale and retail trade; repairs	50t52	45t47, 95
Hotels and restaurants	55	55t56
Transport and storage	60t63	49, 50, 51, 52, 79
Post and telecommunications	64	53, 61
Finance and insurance	65t67	64t66
Real estate activities	70	68
Renting of machinery and equipment	71	77
Computer and related activities	72	62t63
Research and development; Other Business Activities	73t74	69t75, 78, 80t82
Public admin. and defence; compulsory social security	75	84
Education	80	85
Health and social work	85	86t88
Other community, social and personal services	90t93	37t39, 59t60, 90t93, 94, 96

Source: OECD.

Table A.2. Summary Statistics for Production Deflator and GVC Backward Participation Indicator

Unit of observation: industry-year,
 Δ denotes five-year long difference of log variable

	$P_{c,s,t}$	$GVC_{c,s,t}$	$\Delta P_{c,s,t}$	$\Delta GVC_{c,s,t}$
Mean	456.762	23.937	0.108	0.072
Median	95.350	21.84	0.092	0.071
St. dev.	2040.526	14.563	0.141	0.196
N	11,903	11,797	8,492	8,492

Table A.3. Prices and global value chains for pre-crisis period

Estimation method – five-year long differences

	$\Delta P_{c,s,t}$		
	(1)	(2)	(3)
$\Delta GVC_{c,s,t}$	-0.0628*** (0.0199)	-0.0651*** (0.0222)	-0.0436** (0.0195)
Country*Year fixed effects	YES	YES	YES
Industry fixed effects	YES	NO	NO
Industry*Year fixed effects	NO	YES	YES
Country*Industry fixed effects	NO	NO	YES
Observations	3,722	3,722	3,722
Adj R-squared	0.591	0.611	0.867

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The price level and the GVC indicator are measured in log terms. The time period is in principal 1995-2006.

Table A.4. Prices and global value chains, with prices changes one period ahead as the dependent variable

Estimation method – five-year long differences

	$\Delta P_{c,s,t+1}$		
	(1)	(2)	(3)
$\Delta GVC_{c,s,t}$	-0.0498*** (0.0139)	-0.0378** (0.0152)	-0.0297* (0.0172)
Country*Year fixed effects	YES	YES	YES
Industry fixed effects	YES	NO	NO
Industry*Year fixed effects	NO	YES	YES
Country*Industry fixed effects	NO	NO	YES
Observations	7,861	7,861	7,861
Adj R-squared	0.580	0.644	0.810

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The price level and the GVC indicator are measured in log terms. The time period is in principal 1995-2014.

Table A.5. Prices, global value chains and structural factors

Estimation method – five-year long differences

	$\Delta P_{c,s,t}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta GVC_{c,s,t}$	-0.0549*** (0.0132)	-0.0540*** (0.0133)	-0.0558*** (0.0132)	-0.0549*** (0.0133)	-0.0973*** (0.0356)
Structural / policy indicators	None	$\Delta EPL_{c,t} \times$ Layoff _s	Δ Regulatory impact _{c,s,t}	$\Delta EPL_{c,t} \times$ Layoff _s and Δ Regulatory Impact _{c,s,t}	$\Delta ICT_{c,s,t}$
Country*Year fixed effects	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES
Observations	5,547	5,547	5,547	5,547	2,893
Adj R-squared	0.595	0.576	0.576	0.576	0.534

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. All variables are measured in log terms. To ensure exogeneity of the sector level exposure variables, layoff rate is that of the United States. Similarly, the regulatory impact indicator uses the United States input-output structure. For these reasons, the United States is excluded from the analysis of the first 4 columns. The change in ICT intensity is measured by the differential growth rate between ICT and non-ICT real capital services at the country-industry level. The time period is in principal 1995-2014.

Table A.6. Prices, global value chains and import share

Estimation method – five-year long differences

	$\Delta P_{c,s,t}$		
	(1)	(2)	(3)
$\Delta GVC_{c,s,t}$	-0.0557*** (0.0151)	-0.0520*** (0.0171)	-0.0451** (0.0187)
$\Delta \text{import share}_{c,s,t}$	-0.00596 (0.00547)	-0.00742 (0.00624)	-0.00293 (0.00698)
Country*Year fixed effects	YES	YES	YES
Industry fixed effects	YES	NO	NO
Industry*Year fixed effects	NO	YES	YES
Country*Industry fixed effects	NO	NO	YES
Observations	8,492	8,492	8,492
Adj R-squared	0.578	0.645	0.802

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The price level, GVC indicator and import share are measured in log terms. The time period is in principal 1995-2014.

Table A.7. Prices and foreign valued added embodied in final demand

Estimation method – five-year long differences

	$\Delta P_{c,s,t}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta GVC_{c,s,t}$	-0.0698*** (0.0163)				
$\Delta \text{ForeignVA in final dem}_{c,s,t}$		-0.0247** (0.0104)	-0.0343*** (0.00872)	-0.0301*** (0.00833)	-0.0278*** (0.00670)
Foreign VA in final demand enters as a share of:		Production	Value added	Consumption	Domestic VA in final demand
Country*Year fixed effects	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES
Observations	6,594	6,594	6,594	6,594	6,594
Adj R-squared	0.605	0.601	0.603	0.604	0.603

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The price level, GVC indicator and foreign valued added embodied in final demand are measured in log terms. The time period is in principal 1995-2011.

Table A.8. Inflation, global slack and foreign valued added embodied in final demand

Estimation method – annual

	(1)	(2)	$\Delta P_{c,s,t}$ (3)	(4)	(5)	Pre-crisis (6)
ForeignVA in final dem. _{c,s,t}	-0.00268** (-0.00121)	-0.00230* (0.00135)	-0.00244* (0.00136)	-0.00218* (0.00120)	-0.00223 (0.00363)	-0.00337 (0.00444)
Foreign YGap	0.0119*** (-0.00294)	0.0115*** (0.00288)	0.0118*** (0.00290)	0.0120*** (0.00290)	0.0118*** (0.00278)	0.00953*** (0.00312)
Foreign YGap*FVA in f.d. _{c,s,t}	0.00159*** (0.000496)	0.00256*** (0.000479)	0.00219*** (0.000407)	0.00205*** (0.000358)	0.00620*** (0.00115)	0.0112*** (0.00177)
Domestic YGap*FVA in f.d. _{c,s}	-0.00038 (-0.000254)	-0.000508** (-0.000239)	-0.000334 (0.000230)	-0.000378* (0.000201)	-0.000757 (0.000668)	3.81e-05 (0.000666)
Foreign VA in final demand enters as a share of:	Production	Value added	Consumption	Domestic VA in final demand	N/A. Foreign VA as share of exports	N/A. Foreign VA as share of exports
Country*Year fixed effects	YES	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES	YES
Observations	9,268	9,268	9,268	9,251	9,268	6,204
Adj R-squared	0.285	0.290	0.290	0.293	0.293	0.282

Note: Cluster robust standard errors (at the country-industry level) in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. YGap measured as per cent of a country's estimated potential output. YGap < 0 (or >0) for an economy that is below (or above) potential output. Industry producer price inflation is the annual change in the log of the industry production deflator. The foreign value added embodied in final demand and GVC variables are measured in log terms and demeaned by their sample average. For columns 1-5, the time period is in principal 1995-2011, for column 6 1995-2006.

Annex B.

1. Measuring market power using firm-level data²⁴

1. The firm- and time-varying mark-up is derived from the supply-side approach originally proposed by Hall (1986) and more recently re-explored by De Loecker and Warzynski (2012). As described in De Loecker and Warzynski (2012), the approach computes mark-ups without needing assumptions about the demand function, but only relying on available information on output and inputs, under the assumptions that at least one input is fully flexible and that firms minimize costs. Thus, the mark-up – defined as the ratio of the output price P over marginal cost MC – is derived from the first order condition of the firm's cost minimization problem with respect to the flexible input k as:

$$\mu_{it} = \frac{P_{it}}{MC_{it}} = \text{Output Elasticity}_{ikt} / \text{Output Share}_{ikt},$$

2. That is, the mark-up of firm i at time t can be computed as the ratio between the elasticity of output with respect to the flexible input k and flexible input k shares in output (observed in the data). The elasticity of output is estimated via the GMM-based Wooldridge (2009) production function estimation approach, with revenues as a measure for gross output and fixed assets, employment and intermediate inputs (defined as the difference between revenues and value added) as the input variables. Among these, we use intermediate inputs as the flexible input variable and we denote its estimated coefficient by $\hat{\beta}_{II}^j$ for all firms that operate in industry j . Thus mark-ups μ_{it} for each firm i and year t are calculated as the ratio between the estimated production function parameter $\hat{\beta}_{II}^j$ and the intermediate input share iis_{it} :

$$\mu_{it} = \frac{\hat{\beta}_{II}^j}{iis_{it}}.$$

The denominator above, iis_{it} is obtained by dividing intermediate inputs by “corrected” firm-level revenues $\widetilde{R}_{it}$:

$$iis_{it} = \frac{\Pi_{it}}{\widetilde{R}_{it}}$$

3. $\widetilde{R}_{it}$ is obtained as a prediction from a rich polynomial function of observable inputs in order to retain only the anticipated part of output developments:²⁵ The rationale

24. The description below largely builds on Andrews, Criscuolo and Gal (2016).

25. The polynomial includes all possible interactions between labour, capital and materials containing first and second degree terms, along with first and second degree base effects. This follows the Stata code provided by De Loecker and Warzynski (2012) with their online Appendix, with the difference that for computational reasons we omitted the third degree terms.

for using this correction is the assumption that firms do not observe unanticipated shocks to production when making optimal input decisions.

4. As De Loecker and van Biesebroeck (2016: 25) note, the intuition behind this mark-up measure is as follows:

“Holding other inputs constant, a competitive firm will expand its use of [the flexible input, i.e. labour] until the revenue share equals the output elasticity [hence the mark-up measure would be 1]. [...] If a firm does not increase [its flexible input use] all the way until equality holds, but prefers to produce a lower quantity and raise the output price instead, it indicates the firm is able to exercise market power and charge a price above marginal cost.”

5. To obtain sector-level mark-ups, the firm-level measures are aggregated to the country-industry-year level, at the same level of sectoral detail and classification as the rest of our sector-level database (in ISIC Rev.3 at the 2-digit level):

$$Markup_{cjt} = \sum_{i \in c_j} w_{it} \log(\mu_{it}).$$

6. The aggregation uses revenue weights to reflect the importance of firms with more sales in total sectoral output (De Loecker and Eeckhout, 2017), hence:

$$w_{it} = \frac{R_{it}}{\sum_{i \in c_j} R_{it}}.$$