Price Competitiveness in the European Monetary Union: A Decomposition of Inflation Differentials based on the Leontief Input-Output Price Model for the period 2000 to 2014[1]

Andreas Eder[a], Wolfang Koller[a], Bernhard Mahlberg[a,b,2]

[a] Institute for Industrial Research, Mittersteig 10/4, 1050 Vienna, Austria and
[b] Vienna University of Economics and Business, Welthandelsplatz 1, 1020 Vienna, Austria

Abstract

This paper studies the persistent producer price inflation differentials within the European Monetary Union. By applying a decomposition procedure within the input output framework, the drivers of sectoral producer price inflation in a representative sample of member states are revealed. We find that in the pre-crisis period (2000-2008) the inflation differentials in manufacturing and market services of all countries vis-à-vis Germany were consistently positive resulting in a loss of price competitiveness for all economies. Manufacturing and market service sectors of many countries continued to lose price competitiveness, though to a lesser extent, also during the crisis period (2009-2014). We observe that differences in unit labour cost developments across countries constitute an important driver, especially in the pre-crisis period. Other drivers, such as import costs, intermediate input costs and operating surpluses also contribute, in particular during the crisis period.

Keywords: European Integration, Producer Price Inflation, Real Exchange Rates, Gross Output Price Deflators, National Accounts

JEL codes: D57, E31, F15, O57

[1] The authors gratefully acknowledge the valuable comments received on earlier versions of this paper from Mikulas Luptacik and the participants of the Annual Meeting of the Austrian Economic Association 2019 in Graz (Austria). Special thanks to the Groningen Growth and Development Centre (GGDC) for providing the original value added data matching to the WIOD Release 2016. The authors would like to thank the Anniversary Fund of the Oesterreichische Nationalbank for supporting the project under project number 17040. The usual disclaimer applies.

[2] Corresponding author. Tel.: +43 1 513 44 11 2040, Fax: +43 1 5143 44 11 2099, E-Mail-Addresses: Eder@iwi.ac.at (A. Eder), Mahlberg@iwi.ac.at (B. Mahlberg), Koller@iwi.ac.at (W. Koller)

I. Introduction

Diverging competitiveness between the North and South of Europe after the introduction of the single currency in 1999 is at the heart of the discussion about the origins of the Eurozone crisis (see Johnston and Regan, 2016; Nölke, 2016; Höpner and Lutter, 2018). In fact, the conventional wisdom is that the crisis has been driven, in part at least, by competitiveness losses in periphery countries, which led to unsustainable current account imbalances (Wyplosz, 2013; Storm and Naastepad, 2015).[3] Different concepts and measures of competitiveness exist and are applied in the economic literature. The above cited literature largely focuses on comparisons of unit labour cost developments as a measure of price competitiveness but does not take into account the development of other production costs, such as intermediate input unit costs, import unit costs, as well as unit profits and unit taxes, which are, taken together, by far the largest determinants of producer prices (i.e. gross output prices). Furthermore, only direct unit labour costs, but not the indirect labour costs contained in intermediate goods, are considered in the literature. Other measures of international price competitiveness, based e.g. on indicators of export prices, producer prices of the manufacturing sector, consumer prices and GDP deflators, suffer from misleading coverage of sectors or incomplete coverage of production costs (see Fischer et al., 2018).

The aim of this paper is to analyse i) the persistence and ii) the drivers of producer price inflation differentials for a sample of member states of the European Monetary Union (EMU) between 2000 and 2014. In a currency union, different developments in producer prices/price competitiveness among monetary union member states constitute a major challenge for monetary policy-making. Absent the possibility of adjusting nominal exchange rates (revaluing national currencies) and national inflation targeting, movements in bilateral real exchange rates of EMU member states follow the path of inflation differentials. As such, inflation differentials play an important role for equilibrium, stability and relative competitiveness among EMU member states. Diverging and persistent differences in price competitiveness can have detrimental effects on the process of European integration.

Contrary to the previous literature focusing on consumer price inflation differentials in the EMU, reviewed by de Haan (2010), we focus on producer prices dealing more closely with the competitiveness of producers than the consumer price approach (for details see section II). Calculating inflation differentials based on gross output price deflators, which is rarely done, enables us to cover the broadest range of production costs, including intermediate input unit costs, import unit costs, unit profits and unit taxes. In addition, the period of investigation is extended to the years after the financial crisis.

The main novelty of our approach to analyse inflation differentials is that it is based on the Leontief input-output model (Leontief, 1951) and the SDA approach developed by Fujikawa et al. (1995) and Fujikawa and Milana (2002). Building on national industry accounting identities as well as Leontief input-output price models allows us i) to identify the drivers of producer price inflation differentials on an industry-level and ii) to explicitly model indirect unit costs, i.e. the primary input costs contained in intermediate goods. Conducting such an analysis on an industry-

[3] Whether or not losses in competitiveness of some EMU countries are the cause or just a symptom of the Euro zone crisis is disputed and is beyond the scope of this paper.

level is of particular importance for two reasons. First, the evolution of prices in the non-traded goods sector has little to say about external competitiveness and a distinction between tradable and non-tradable sectors is needed to draw the right conclusions. Second, national economies have differing industrial compositions and may compete successfully in one industry while performing not so well in others.

In addition, the methodological section of this paper provides a conceptual link between two strands of literature: growth accounting (GA) and structural decomposition analysis (SDA). GA and SDA have been often used to decompose output changes (economic growth) between two or more years into different components, such as growth rates of inputs and total factor productivity growth in the case of GA (see e.g. Hulten, 2010) or productivity changes, structural changes and final demand changes in the case of SDA (see e.g. Rose and Casler, 1995). However, the application of these methods to decompose price changes (inflation) is seldom (c.f. section 2), and our study is the first comprehensive attempt to apply these methodologies to decompose inflation differentials.

Our analysis is based on extensive input-output tables combined with detailed socio-economic accounts for the period 2000-2014 taken from the World Input Output Database (see Timmer et al., 2016). Inflation differentials are calculated for Austria, Belgium, Estonia, France, Greece, Italy, Netherlands, Portugal and Slovenia relative to Germany (details on sample selection are provided in section III). For the presentation of the results, we divide the observation period into two sub-periods, one for the years before the financial and economic crisis (2000 to 2008) and one for the years during the financial and economic crisis (2009 to 2014), and group the sectors into four broad categories – manufacturing, market services, non-market services and others. Since we are mainly interested in international price competition, the results section focuses on inflation differentials in the tradable goods sectors covering manufacturing and market services.

We find that in the pre-crisis period (2000-2008) the inflation differentials in manufacturing and market services of all countries vis-à-vis Germany were consistently positive resulting in a loss of price competitiveness for all economies. Manufacturing and market service sectors of many countries continued to lose price competitiveness vis-à-vis Germany, though to a lesser extent, also during the crisis period (2009-2014). The drivers of inflation differentials across countries are quite heterogeneous. Though, we observe that differences in unit labour cost developments across countries constitute an important driver, especially in the pre-crisis period. Other drivers, such as diverging developments in import unit costs, intermediate input unit costs and unit operating surpluses, are not negligible and are of particular importance during the crisis period.

The remainder of the paper is structured as follows: section II provides a brief literature review and section III discusses the methodological approach. Section IV presents the data base and section V provides the empirical results for selected EMU countries. Finally, section VI summarizes our findings and draws conclusions.

II. Literature Review

A number of studies have analysed the size and persistence of inflation differentials in the EMU, mainly motivated by the importance of inflation differentials for the long-term stability of a currency union and the main objective of the European Central Bank (ECB) to secure stability of

consumer prices (e.g., Honohan and Lane 2003; Altissimo et al., 2005; Hofmann and Remsperger, 2005; Angeloni and Ehrmann, 2007; Busetti et al., 2007; Egert, 2007; Aldasoro and Žďárek, 2009; Andersson et al., 2009; Beck et al., 2009; Lagoa, 2017). An excellent review of this literature can be found in de Haan (2010). However, when measures of external price competitiveness are required real exchange rates based on consumer price indices (CPIs) have several drawbacks. First, CPIs do not cover prices of capital goods and intermediate input goods. While the former constitute a major part of foreign trade the latter are a major cost component of production. Second, CPIs cover prices of non-tradable consumer goods which do not compete with comparable goods from foreign providers (Fischer et al., 2018). Moreover, consumer prices can be distorted due to taxes and subsidies.

The methodological framework for studying inflation differentials in this paper is based on the Leontief input-output model (Leontief, 1951) and the SDA approach developed by Fujikawa et al. (1995) and Fujikawa and Milana (2002). Fujikawa and Milana (2002) decompose sectoral output price gaps between Japan and China into differences in intermediate input unit costs, differences in labour unit costs, differences in capital unit costs and unit costs of other primary inputs. The unit cost components of intermediate inputs, labour and capital are further decomposed into productivity and price components, e.g. differences in unit labour costs between Japan and China are decomposed into differences in labour productivity and wages. Not only the direct effects of differences in prices and productivities of factors of production but also the indirect effects – primary input prices and productivities embedded in prices of intermediate inputs sourced from upstream sectors – are considered explicitly.

We modify the decomposition of Fujikawa and Milana (2002) in order to decompose price changes (inflation rates) of single countries over time instead of comparing price gaps between countries. Subtracting the time series of inflation of one country from the times series of inflation of the reference country, i.e. Germany, gives the inflation differential and the corresponding decomposition. Our framework goes beyond that of Fujikawa and Milana (2002) by explicitly considering drivers of inflation differentials such as different developments in unit costs of imported intermediate inputs as well as different developments in unit operating surpluses, unit consumption of fixed capital and unit taxes less subsidies.

Decomposition approaches for the analysis of inflation and competitiveness are, of course, not new and have occasionally been used on a macroeconomic and sectoral level: Our approach is closely related to an approach called "price analysis" introduced by De Boer and van Tuinen (1979), Donkers (1982), Donkers and van der Zwan (1986) which is also based on the Leontief input output price model and includes the indirect effects from upstream sectors. Similar to the above presented model it takes into account the relationship between changes in output prices and in unit costs of inputs. The main target of this initiative was to provide sectoral price statistics for the Netherlands both as an "intermediate input" for the compilation of other statistics and as a "final product". The systems of price analysis comprise a decomposition of price changes of various aggregates (total final demand and its categories, industry output) according to the direct and indirect influences of price changes of production factors and changes in production structure. The unit input cost developments are considered as price developments of inputs adjusted for productivity changes.

A similar approach, motivated by the broad subject of cost-push inflation and related to the decomposition of wholesale price indexes, has also been presented by Nordhaus and Shoven (1977). These authors devise modifications of the input-output price model that not only consider prices of primary inputs as exogenous but also those of selected intermediate inputs, in particular raw materials (e.g. agricultural commodities, forest products, crude oil). Marczewski (1978) provides a framework based on national accounting data to decompose inflationary gaps, defined as the difference between the nominal and the real growth of national accounting aggregates (e.g. GDP plus imports), to analyse the inflationary process in France during the period 1966 to 1976.

Meyler (2001) uses an inflation accounting approach to examine the relative contribution of labour costs, profits and indirect taxation to the evolution of the euro area GDP deflator over the period 1960-2000. A series of reports of the ECB (2003, 2005, 2006, and 2008) decompose growth rates of final demand deflators and GDP deflators and, respectively, the differentials in these indicators of member countries relative to the euro area average. Based on national accounts they attribute the inflation differentials to changes in unit costs (further decomposed into price and productivity components) of production factors (e.g., labour and capital).

III. The method of price analysis

Our method of price analysis is very close to the one developed by Fujikawa et al. (1995) and Fujikawa and Milana (2002). It is based on the Leontief price model (Leontief, 1951) and a structural decomposition analysis (SDA). In empirical applications structural decomposition analysis is often introduced in an ad-hoc manner as a sequence of static comparisons or developed with the help of the theoretical perspective of index theory. In the following we develop the concept of price accounting according to its close analogy to growth accounting (see also Fujikawa et al., 1995).

Growth accounting is, at least to economists, a well-known procedure to measure the contribution of different factors to economic growth and to compute the rate of technological progress, measured as a residual, in an economy. As clarified by e.g. Hulten (2010) "Growth accounts are a natural by-product of the basic national-accounting identity." As shown by Jorgenson and Griliches (1967) as well as Hsieh (2002), the primal and the dual measure of total factor productivity growth (Solow, 1957) – also known as Solow-residual – can be derived from the national income accounting identity, stating that aggregate output (income) is equal to the payments to the factors of production, e.g. capital and labour.

The point is, that neither assumptions about the existence or the form of a production function, nor assumptions about the relationship between factor prices and their social marginal products, are necessary for growth accounting. The nature of growth accounting can be purely empirical and atheoretical. The main contribution of Solow (1957) was the explicit integration of economic theory into such calculations (Griliches, 1996) by i) introducing a production function with constant returns to scale, ii) assuming that factors are paid their marginal products and iii) that factor shares are roughly constant. Instead of deriving a measure of productivity growth from the accounting identity, Solow (1957) derives its measure from a Cobb-Douglas production function by assuming a neoclassical theory of income distribution. However, as argued by McCombie (2000), the Cobb-Douglas production function, by using the aforementioned assumptions, can be shown to be nothing more than a power function approximation of the linear accounting identity.

Growth accounting is widely applied by economists and generally accepted among them as a method for assessing the contribution of different factors to output growth; no matter if output is measured as value added or as gross output. However, such calculations can not only be applied to output growth but also to price changes serving as a means to assess the contribution of different factors to inflation, which can be measured, e.g., as the growth rate of a value added deflator or a gross output deflator. Since this study analyses inflation on a sectoral level, we consider gross output as the appropriate measure of output (Hulten, 2010) and start with the following industry (or company) accounting identity:

$$p_i(t)X_i(t) = w_i(t)L_i(t) + r_i(t)K_i(t) + \sum_{j=1}^{n} p_{ji}(t)Z_{ji}(t) + \sum_{h=2}^{g}\sum_{j=1}^{n} p_{hji}(t)M_{hji}(t) \quad (1)$$

This equation goes beyond the usual growth accounting framework in that it explicitly discerns between domestic intermediate inputs (inputs from country $h = 1$) and imported intermediate inputs (inputs from country $h = 2, \dots, g$). The subscript $i = 1, \dots, n$ represents sectors. The value of sectoral gross output (=total input costs) is given by the price of gross output, p_i, multiplied by the quantity of gross output, X_i. Furthermore, w_i is the price of labour (wage), r_i is the rental price of capital, L_i is the quantity of labour and K_i, is the quantity of capital. Labour (capital) compensation is $w_i L_i$ ($r_i K_i$). Sectoral value added is the sum of labour and capital compensation. The value of gross output of sector i exceeds the value of sectoral value added, $w_i L_i + r_i K_i$, by the value of intermediate inputs purchased from domestic or foreign sources, a distinction which has been made explicit by introducing two different terms in the equation. Domestic intermediate inputs (i.e., inputs from country $h = 1$) are given by Z_{ji} where j denotes the sector of the input. Prices of domestic intermediate inputs of sector j possibly vary according to buying sector i and, therefore, are denoted by p_{ji}. Imported intermediate inputs sourced by sector i from sector j in country h are given by M_{hji} and carry prices p_{hji}. Note that p_i, p_{ji} and p_{hji} are different variables, thus avoiding any implicit assumption of homogenous prices at this point.

Dividing by the quantity of gross output X_i on both sides of equation (1) leads us to the price equation (2) which states that the output price of sector i is given by its average costs, including labour costs per unit of output (unit labour costs), capital costs per unit of output[4], plus expenditures for intermediate inputs per unit of output.

$$p_i(t) = w_i(t)l_i(t) + r_i(t)k_i(t) + \sum_{j=1}^{n} p_{ji}(t)\, z_{ji}(t) + \sum_{h=2}^{g}\sum_{j=1}^{n} p_{hji}(t)m_{hji}(t) \quad (2)$$

Here, $l_i = L_i/X_i$ describes how much labour (e.g. hours) is needed for the production of one unit of gross output in sector i. The labour requirement coefficient, l_i, is equivalent to the inverse of labour productivity. Similarly, $k_i = K_i/X_i$, $z_{ji} = Z_{ji}/X_i$ and $m_{hji} = M_{hji}/X_i$ describe how much capital, how many units of domestic intermediate input j and how many units of imported input j from country h are needed for the production of one unit of gross output in sector i, respectively. Hence, k_i represents the capital requirement coefficient and z_{ji} and m_{hji} denote domestic and imported intermediate input coefficients, which are the inverse of the capital productivity and the intermediate input productivities, respectively.

[4] Capital costs per unit of output may include depreciation of capital but also industry operating surplus per unit of output, which can be considered as costs from a macroeconomic perspective, since they drive up industry prices.

Differentiating $p_i(t)$ with respect to time gives the time derivatives, given by equation (3), where the dot is used to denote the time derivative. The time derivative of gross output price is a weighted sum of the time derivatives of labour price (=wages), labour requirements, capital price, capital requirements, domestic intermediate input prices, domestic intermediate input requirements, imported intermediate input prices and imported intermediate input requirements, where the weights are either input requirements for price change components and prices for the input requirement change components. Hence, equation (3) allows assessing the contribution of input price changes and input requirement changes (or input productivity changes) to price changes.[5]

$$\frac{\partial p_i(t)}{\partial t} = \dot{p}_\iota(t) = \dot{w}_i(t)l_i(t) + w_i(t)\dot{l}_i(t) + \dot{r}_i(t)k_i(t) + r_i(t)\dot{k}_i(t) + \sum_{j=1}^{n} \dot{p}_{ji}(t)z_{ji}(t) +$$

$$\sum_{j=1}^{n} p_{ji}(t)\dot{z}_{ji}(t) + \sum_{h=2}^{g}\sum_{j=1}^{n} \dot{p}_{hj}(t)m_{hji}(t) + \sum_{h=2}^{g}\sum_{j=1}^{n} p_{hji}(t)\dot{m}_{hji}(t) \quad (3)$$

Adding up the terms which capture the contribution of labour price changes (first term on the right-hand side) and the contribution of labour requirement changes (second term on the right-hand side) to price changes gives the contribution of changes in nominal unit labour costs to gross output price change. Similarly, we can assess the contribution of the change of nominal unit capital costs and the change of nominal unit intermediate input costs to price changes by adding up the terms which capture price change and requirement change of the respective inputs.

Further dividing (3) by $p_i(t)$ leads to an accounting equation of the growth rate (inflation rate) of gross output prices of sector i:

$$\frac{\partial p_i(t)}{\partial t}\frac{1}{p_i(t)} = \frac{\partial \ln(p_i(t))}{\partial t} = \frac{\dot{p}_\iota(t)}{p_i(t)} = \frac{\dot{w}_\iota(t)}{w_i(t)}s_{L_i}(t) + \frac{\dot{l}_\iota(t)}{l_i(t)}s_{L_i}(t) + \frac{\dot{r}_\iota(t)}{r_i(t)}s_{K_i}(t) + \frac{\dot{k}_\iota(t)}{k_i(t)}s_{K_i}(t)$$

$$+ \sum_{j=1}^{n}\frac{\dot{p_{j\iota}}(t)}{p_{ji}(t)}s_{j_i}(\mathrm{t}) + \sum_{j=1}^{z}\frac{\dot{z_{j\iota}}(t)}{z_{ji}(t)}s_{j_i}(\mathrm{t}) +$$

$$+ \sum_{h=2}^{g}\sum_{j=1}^{n}\frac{\dot{p_{hj\iota}}(t)}{p_{hji}(t)}s_{hj_i}(\mathrm{t}) + \sum_{h=2}^{g}\sum_{j=1}^{n}\frac{\dot{m_{hj\iota}}(t)}{m_{hji}(t)}s_{hj_i}(\mathrm{t}) \quad (4)$$

where s_{L_i}, s_{K_i}, s_{ji}, and s_{hji} are the share of labour cost in the value of gross output of sector i, $(w_i l_i/p_i)$, the share of capital cost in the value of gross output of sector i, $(r_i k_i/p_i)$, the share of the cost of domestic intermediate input j in the value of gross output of sector i, $(p_{ji}z_{ji}/p_i)$, and the share of the cost of imported intermediate input j imported from country h in the value of gross output of sector i, $(p_{hji}m_{hji}/p_i)$, respectively.

Equation (4) shows that the growth rate (inflation rate) of gross output price is a weighted sum of the growth rate of labour price, capital price, and the growth rates of (domestic and imported) intermediate input prices, as well as the growth rate of labour requirement, capital requirement and the growth rates of (domestic and imported) intermediate input requirements. Here, the weights for the growth rates of these variables are their respective value shares in gross output.

[5] By differentiating between domestic and foreign intermediate inputs we can assess the contribution of import price change and import productivity change on price change. This allows distinguishing between home-made inflation and imported inflation.

Equation (4) allows assessing the contribution of input price growth and input requirement growth (or input productivity growth) to the inflation rate.

Equation (3) and (4) are denoted in continuous time. Since national accounting data is collected and reported in discrete-time applying decomposition (3) and (4) requires discrete approximations. Integrating both sides of equation (3) from period t to period $t+1$ yields a decomposition of the price change from period 0 to period 1 for sector i, $p_i(t+1) - p_i(t)$, for which an exact discrete-time approximation introduced by Bennet (1920) exists, see Fujikawa et al. (1995). Integrating both sides of equation (4) from period t to period $t+1$ yields a decomposition of the price growth from period 0 to period 1 for sector 1, $\ln(p_i(t+1)) - \ln(p_i(t))$, for which a good discrete-time approximation can be formulated by Törnqvist indices, see Fujikawa et al. (1995). Since the discrete-time approximation by Törnquvist indices is not exact and an approximation error remains (see e.g. Trivedi, 1981), we decide to rely on Bennet's discrete-time approximation:

$$\Delta p_i = \Delta w_i \emptyset l_i + \emptyset w_i \Delta l_i + \Delta r_i \emptyset k_i + \emptyset r_i \Delta k_i + \sum_{j=1}^{n} \Delta p_{ji} \emptyset z_{ji} + \sum_{j=1}^{n} \emptyset p_{ji} \Delta z_{ji}$$

$$+ \sum_{h=2}^{g} \sum_{j=1}^{n} \Delta p_{hji} \emptyset m_{hji} + \sum_{h=2}^{g} \sum_{j=1}^{n} \emptyset p_{hj}\, \Delta m_{hji} \qquad (5)$$

With the switching over to a discrete time framework we have found it useful to introduce several notational simplifications. The difference operator Δ denotes taking the difference of a variable between period t and $t+1$, e.g., $\Delta p_i = p_i(t+1) - p_i(t)$. The averaging operator $\emptyset$ denotes the average of a variable observed at period t and $t+1$, e.g, $\emptyset l_i = \frac{1}{2} l_i(t) + \frac{1}{2} l_i(t+1)$. Furthermore, from now on we drop the time variable and any observed variable is either assumed to be observed at period t or as implied by the used operator. Note that in equation (5) the input price changes are weighted by an average of the respective input requirements of period t and $t+1$ and the weights of the input requirement changes are an average of the respective input prices from period t and $t+1$.

In order to make the notation even more compact, we translate equation (5) into matrix notation. For that, all primary input requirement coefficients, l_i, k_i and m_{hj} are collected in primary input coefficient matrix D, the prices associated with primary inputs in vector v, all intermediate input coefficients z_{ji} are collected in intermediate domestic input coefficients A and the prices associated with intermediate inputs in matrix P. Thus, the vector of price changes Δp and its decomposition can be written in matrix notation as follows:

$$\Delta p = \Delta v \emptyset D + \emptyset v \Delta D + e(\Delta P \cdot \emptyset A) + e(\emptyset P \cdot \Delta A) \qquad (6)$$

Here, e is a n-order summation row-vector, i.e. a row-vector of ones, and $\cdot$ denotes the elementwise multiplication of matrices. The use of that particular notation is necessary, because, until now, we have been avoiding the assumption of homogenous prices and allow for different intermediate input prices across producing sectors, $p_{j_1 i} \neq p_{j_2 i}$ for $j_1 \neq j_2$. However, for the sake of simplicity, in the following we can make this assumption and assume $p_{ji} = q_i$ for all j. Note, however, that this implies only a partial homogeneity of prices as we do not assume that $p = q$. After this simplification the accounting equation reads:

$$\Delta p = \Delta v \emptyset D + \emptyset v \Delta D + \Delta q \emptyset A + \emptyset q \Delta A \quad (7)$$

where q is a n-order row vector of domestic intermediate input prices.

The organisation of the primary input coefficients and corresponding prices can be done in the most general way, assuming both sector-specific primary input requirements and prices, e.g. sector-specific wages. Then, D is a $on \times n$-matrix containing the sector-specific primary input coefficients and consists of o diagonal submatrices with dimension $n \times n$. The first diagonal submatrix in D contains the sector-specific input requirements of primary input 1 and the last diagonal submatrix of D covers the sector-specific input requirements of primary input o.

Equation (7) shows that (the vector of) price changes Δp can be decomposed into components representing i) the direct effects of the changes of primary input prices, ii) the direct effect of changes of primary input requirements (productivities), iii) the direct effects of changes of intermediate input prices and, iv) the direct effects of changes of intermediate input requirements (productivities).

So far, equation (7) represents a pure accounting model as all variables on the right side are considered exogenous and the only modelling assumption is that input costs sum up to give the value of output (accounting assumption). When we go beyond that framework and additionally assume homogenous prices for all uses, $p = q$, we have endogenized intermediate input prices and have the well-known Leontief price model, which can be solved in the usual way:

$$\Delta p = \Delta v \emptyset D (I - \emptyset A)^{-1} + \emptyset v \Delta D (I - \emptyset A)^{-1} + \emptyset p \Delta A (I - \emptyset A)^{-1}, \quad (8)$$

where I is a n-dimensional identity matrix.

According to equation (8) price changes can be decomposed in components representing i) the direct and indirect effects of changes of primary input prices, ii) the direct and indirect effect of changes of primary input requirements (productivities) and iii) the direct and indirect effect of changes of intermediate input requirements (productivities). The indirect effects can be calculated by subtracting the respective direct effects in (7) from the total effects in (8). Thus, the indirect effects are given by a multiplication of the respective direct components in (7) with the matrix $\emptyset A (I - \emptyset A)^{-1} = (I - \emptyset A)^{-1} - I$. Thus, we can decompose each term on the right side of equation (8) into a direct and an indirect effect.

$$\begin{aligned} \Delta p = {} & \Delta v \emptyset D + \Delta v \emptyset D \emptyset A (I - \emptyset A)^{-1} + \\ & \emptyset v \Delta D + \emptyset v \Delta D \emptyset A (I - \emptyset A)^{-1} + \\ & \emptyset q \Delta A + \emptyset q \Delta A \emptyset A (I - \emptyset A)^{-1}, \end{aligned} \quad (9)$$

Comparison with equations (7) reveals that in equation (9) there is no component which explicitly is related to the effects of domestic intermediate input prices. The third component in equation (7) is distributed among the components in (8), such that the sum of all indirect effects is equal to the direct component of intermediate input price changes. Hence, the three distinct indirect effects constitute a decomposition of the direct component of intermediate input price changes.

This relationship must be understood in the context of the different modelling assumptions of equations (7) and (8), in particular the assumption of endogeneity or exogeneity of domestic intermediate input prices.

Differences in direct intermediate input price developments across countries can make up more than two thirds of the inflation differential. Therefore, it is important to decompose the direct intermediate input price component and evaluate the drivers behind these changes: Are these changes due to input price changes or input productivity changes of suppliers and suppliers of the suppliers, and so on...

Multiplying equation (9) on both hand sides by the $n \times n$-dimensional matrix $\widehat{p_t}$, which is the inverse of the diagonal matrix containing the gross output prices of the n sectors in period t, gives the inflation rate of gross output prices on the left hand side of the equation, and the contribution of the individual components to this inflation rate on the right hand-side.

Analysing the drivers of sectoral inflation differentials between two countries involves the calculation of (9) for the two countries under investigation, choosing a reference country, and subtracting the reference country's inflation rate vector from the inflation rate vector of the other country as well as subtracting the reference country's diverse vectors of inflation components from the respective vectors of inflation components of the other country.

IV. Data base

To analyse the drivers of inflation differentials across European countries we make use of the World Input Output Database (WIOD) Release 2016 for the years 2000 to 2014. The WIOD provides world input-output tables (WIOT) for the years 2000 to 2014 that cover 43 countries (plus a rest-of-the-world region) and 56 sectors. Thus, they document not only domestic intermediate flows and deliveries to final demand but all bilateral international trade flows, allowing us to identify country and sector of origin as well as country and sector/final demand category of destination. All elements in the WIOTs are nominal and expressed in millions of USD (more details about the WIOTs are provided in Timmer et al., 2015; Timmer et al., 2016).

The WIOD also includes a comprehensive collection of socio-economic accounts (SEAs) data on the industry-level with the same industry classification as the WIOTs. The SEAs cover data on employment, capital stocks as well as gross output and value added deflators. The provision of SEAs data, which are compatible with the WIOTs, motivates the choice of the WIOD as our preferred data source. The comprehensive and consistent collection and provision of employment data and gross output deflators allows us to assign a proper price to the nominal values of intermediate inputs as well as labour compensation and to differentiate between price changes and changes in real values (productivity changes) of these factors of production. Sectoral gross output deflators are taken as prices for domestic intermediate inputs. Labour prices are calculated by dividing labour compensation by total hours worked of employed and self-employed.[6]

The specification of import prices, taking into account national price changes in exporting countries and exchange rates, has not been possible for all exporting countries. In particular, for the

[6] Labour compensation includes compensation of employees, consisting of wages and salaries in cash or in kind and employer's actual and imputed social contributions, as well as mixed income (e.g. remuneration of self-employed).

rest of the world country-unit, containing important exporting countries such as Saudi Arabia, Iran and Iraq, there are no satisfying exchange rates and gross output deflators available. Considering also data issues for other exporting countries (e.g. i) no gross output deflators, only value added deflators are available for countries such as Spain and the United Kingdom; ii) the SEA contains gross output deflators originating from various sources questioning the comparability of those deflators), the decision was made not to use price information for imports.

Additionally, we extend the SEA data by detailed value-added data from Eurostat.[7] These data are delivered in more detail than the SEAs from WIOD as they are structured in compensation of employees, other taxes less other subsidies on production, consumption of fixed capital and operating surplus and mixed income. Using these data, we are able to decompose the broad component of so-called "capital compensation" from WIOD into net operating surplus, consumption of fixed capital and taxes less subsidies on production.

From the nominal WIOT we construct, i.e. we carve out, national input-output tables for 10 European countries between 2000 and 2014, each having 54 sectors[8], and convert them from US$-values into Euro-values. The national, nominal input-output tables are deflated using the national gross output deflators denominated in Euros, which are provided by the SEAs to obtain national input-output tables in real values. In this way we could obtain the real values of intermediate inputs. Real labour input is given by the total hours worked of employed and self-employed, which are taken from the SEAs. The hours worked by self-employed are proxied by the assumption that all self-employed persons work the same number of hours per week/year as employed. Using real values allows us to calculate intermediate and primary input requirements (inverse of factor productivities) by dividing real inputs by real gross outputs. For taxes less subsidies, consumption of fixed capital and operating surplus prices could not be estimated, and the separation of quantities and prices is not possible. Since we consider the quality of available information on import prices as unsatisfactory (see above), we abstain from deflating nominal import values and presenting results on the decomposition of the import unit cost component into a price and a productivity component.

The countries covered in our sample are Austria, Belgium, Estonia, Germany, France, Greece, Italy, Netherlands, Portugal and Slovenia. These countries have been chosen by considering both the requirement of data availability, data quality and comparability as well as the desire to cover a heterogeneous sample of countries participating in the European Monetary Union. Some countries have been excluded from the sample because only value added deflators and not gross output deflators are available. To guarantee comparability of gross output prices only deflators originating from the OECD STAN database are considered, except for Estonia. A further criterion for selection is the congruence of the inflation time-series for the manufacturing sector derived from gross-output deflators in WIOD with the producer price inflation time-series from Eurostat.

[7] The Groningen Growth and Development Centre provided us with the original time series accessed on 15 January 2016. These data match exactly with the value added in the Input-Output-Tables from the WIOD.

[8] The sectors "activities of extraterritorial organizations and bodies", "activities of households as employers" and "other service activities" are pooled together under one sector.

V. Producer Price Inflation differentials within the European Monetary Union

We apply the previously presented model to analyse producer price inflation differentials of selected member states of the EMU vis-à-vis Germany. Germany is considered as the reference country since it can be considered as the leading economy within the EMU constituting the largest economy in terms of total GDP and size of labour market (number of employees). Furthermore, it has the lowest pre-crisis (2000-2008) inflation rates of all selected European countries.[9]

Following the approach of Inklaar and Timmer (2014) we aggregate price developments of 54 individual sectors to form price changes of four groups: manufacturing industries, market services (such as communication, business and transport services, etc.), non-market services (which we define to include public administration, health, education, and real estate) and other sectors (such as agriculture, fishing, forestry, mining, utilities, construction), see Table A2 in the Appendix. This classification is intended to reflect the distinction between tradable (the former two groups) and non-tradable sectors (the latter two). It might be objected that, depending on the used measure, one could also classify some sectors from the group of other sectors as tradable.[10] However, since these sectors include many products that are barely internationally traded (utilities, construction) or in markets distorted by tariffs and subsidies (agriculture) we decided to treat them in the same way non-tradable.

For the presentation of the results, we also divide the observation period into two sub-periods, namely one for the years before the financial and economic crisis (pre-crisis period, 2000 to 2008) and one for the years during and after the financial and economic crisis (crisis period, 2009 to 2014).

Figure 1 and 2 show the growth rates of aggregate producer prices for the sample of 10 European countries between 2000 and 2014. The aggregate inflation rates are a weighted average of the gross output price growth of 54 sectors where the shares of sectoral gross output in total gross output were used as weights.

As can be seen from Figure 1 and 2, the overall producer price inflation rates were for most of the countries by tendency higher before the crisis than during the crisis. During 2009 (the first year of the crisis) the inflation rates decrease considerably in all countries. In 2010 they returned to its level of 2008 for almost all countries. Beginning in 2011/12, the inflation rates decrease again in all countries. With the exception of Greece, the inflation rates remain positive during the crisis, though for many countries close to zero. Greece was the only country which experienced a notable deflation period beginning in 2013 with inflation rates below minus two percent. Estonia and Slovenia are other interesting cases. Slovenia, whose inflation rate in 2000 was particularly high, showed a marked trend toward declining inflation rates, whereas Estonia experienced a different development. Like for other former transition countries, its inflation rate was outstandingly high in 2000. From 2000 to 2003 its inflation rate decreased before it started to increase and reached the highest value in 2007. From 2008 on, the development was similar to other countries.

[9] The choice of Germany concerns only the calculation of inter-country differentials as a last step of the analysis. The preceding steps of the analysis (calculation of gross output inflation and its decomposition) do not depend on the choice of Germany as reference country.

[10] For instance, the ratio of total trade (imports + exports) to total production is above 20 percent for agriculture in many counties of our sample and thus surpasses many of the manufacturing sectors.

Figure 1: Overall producer price inflation in Austria, Germany, Estonia, France and Slovenia

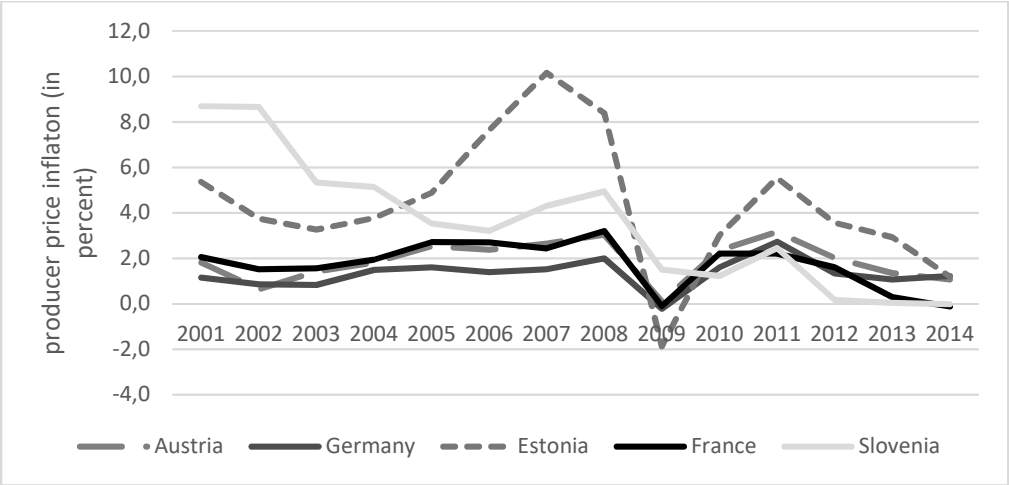

Figure 2: Overall producer price inflation in Belgium, Greece, Italy, Netherlands and Portugal

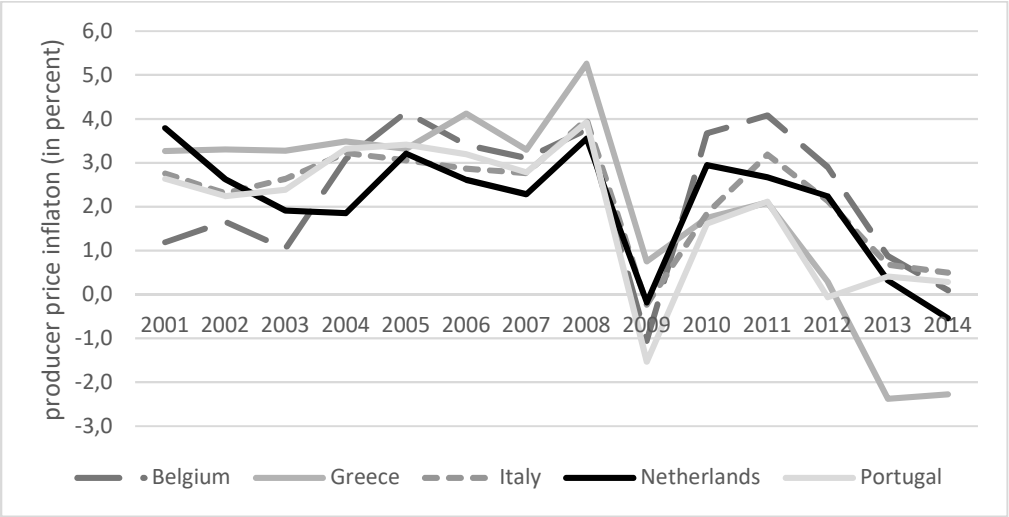

Table 1 shows that in the pre-crisis period 2000 to 2008 overall, as well as in all sector groups, Germany had clearly the lowest inflation rate of all countries in the sample, and all inflation differentials were positive. The differentials were by tendency lower in manufacturing than in market services, non-market services, and other sectors, which could be explained by the higher competitive pressure faced by manufacturing sectors. In this period all countries lost price competitiveness vis-à-vis Germany.

In the crisis period 2009 to 2014 the inflation differentials of almost all countries overall (i.e., in the whole economy) as well as in almost all sector groups were lower than in the previous period. The only exception is the manufacturing sector in Austria. For some countries and sector groups the differentials turned even into negative. The negative differentials are more frequent and more pronounced in non-market services and other sectors. Although the products of these sectors are barely internationally traded, the inflation in these sectors is not completely negligible since some of their products serve as intermediate goods in manufacturing and market services. In this way, their prices influence the prices of manufacturing and market services. In the rest of the paper we report results for manufacturing and market services only, as those represent the part of the

Table 1: Producer price inflation differential (percentage points) by industries and countries relative to Germany

	All industries		Manufacturing		Market services		Non-market services		Other sectors	
	2001-2008	2009-2014	2001-2008	2009-2014	2001-2008	2009-2014	2001-2008	2009-2014	2001-2008	2009-2014
	Producer price inflation in Germany (percent)									
DEU	1.36	1.29	1.60	0.92	1.00	1.19	0.98	1.89	2.56	1.78
	Producer price inflation differentials across countries relative to Germany (percentage points)									
AUT	0.68	0.39	0.02	0.13	0.74	0.46	1.30	0.33	0.39	0.31
BEL	1.32	0.47	1.70	0.51	1.11	0.81	1.81	0.24	0.36	-0.32
EST	4.54	1.10	2.34	0.64	4.57	1.61	6.69	0.83	3.88	0.37
FRA	0.91	-0.27	0.27	-0.02	0.69	-0.43	1.89	-0.64	1.10	-0.12
GRC	2.31	-1.25	2.60	0.58	1.98	-0.71	3.77	-3.14	1.01	-1.82
ITA	1.59	0.06	0.90	-0.13	1.59	0.42	2.98	-0.66	1.09	0.29
NLD	1.37	-0.05	1.51	0.24	1.04	0.32	1.98	-0.44	1.12	-1.29
PRT	1.63	-0.82	0.57	-0.61	1.33	-1.22	2.81	-0.84	1.36	-0.84
SVN	4.12	-0.40	1.87	0.15	5.54	-0.42	4.65	-1.82	3.53	-0.12

Note: Annual average inflation rates for the periods 2001-2008 and 2009-2014 are reported. Inflation rates are a weighted average of the gross output price growth i) of 54 industries for "all industries", ii) of 19 industries for "manufacturing", iii) of 23 industries for "market services", iv) of 4 industries for "non-market services" and v) of 8 industries for "other sectors" (for details see Table A2 in the appendix). The shares of sectoral gross output in total gross output are used as weights. Country codes see Table A1 in the appendix.

economy most exposed to international competition.[11] In manufacturing and market services there was hardly a trend reversal. Rare examples for a reversal were manufacturing in Portugal and to a minor extent in France and Italy as well as the market services in France, Greece, Portugal and Slovenia. These countries and sectors gained price competitiveness vis-à-vis Germany but could not make up for their loss of competitiveness originating before the crisis in the second period. All other countries and sectors continued to lose competitiveness relative to Germany.

In order to show how the producer price analysis works, the decomposition of producer price inflation in Germany is shown here as an example. The results are presented in Table 2. The inflation rate is decomposed in the components import unit costs, intermediate input unit costs, labour unit costs, unit net operating surplus, unit consumption of fixed capital, and unit taxes less subsidies. The components intermediate input unit costs and labour unit costs are, in turn, divided into sub-components of price and productivity. The productivity component is measured as factor requirement indicating the amount of individual production factors required to produce one unit of output in a sector. Factor requirement is equal the inverse of productivity. A positive sign means an increase in requirement and, hence, a decrease of productivity. A decrease of productivity in turn increases producer prices. A negative sign means exactly the opposite. It indicates a decrease in requirement and, hence, an increase in productivity which, in turn, decreases producer prices.

In the *German manufacturing sector* before the crisis (2000 to 2008) the inflation was directly driven by increasing import unit costs and intermediate input unit costs with an ascending effect in magnitude until 2008. The labour unit costs had a dampening effect, the unit capital costs (i.e., net operating surplus plus consumption of fixed capital) increased the inflation rate, and unit net-taxes played a minor role. A closer look at the increasing intermediate input unit costs reveals that they were mainly driven by price increases and only to a minor extent by their productivities. The inflation reducing effect of labour unit cost developments mirrors the fact that labour price growth was lagging behind labour productivity growth. This can be traced back to the policy of wage restraint at that period in the German manufacturing sector (cf. Dustmann et al., 2014). A similar pattern applies to the indirect effects which explains the development of the intermediate input prices and reveals the impact of the upstream sectors. The main driver of intermediate input price increases was raising import unit costs. For the indirect effects the labour costs play a minor role. They dampen the intermediate input price inflation. Contrary to labour unit costs, the unit capital costs contributed to an increase in intermediate input prices and are their second most important driver in the pre-crisis period.

During the crisis (2009 to 2014) the inflation rate in the *German manufacturing sector* decreased strikingly and the role of drivers partly changed. The unit import costs still induced an increase, but contrary to the previous period decreasing intermediate input unit costs dampened and increasing labour unit costs raised the inflation. The productive usage of intermediate inputs increased

[11] Overall inflation is not very meaningful for international competitiveness because it contains price developments of goods not being internationally traded. In particular, the non-market services' and other sectors' share in total inflation is higher than the shares of manufacturing and market services, especially before the crisis. In the crisis period, this pattern partially disappears. For details see Table A3 in the appendix. This is a further argument in favour of focussing on the price development in manufacturing and market services.

markedly and prices increased slower than productivity. Labour productivity considerably decreased while labour price slightly increased. The unit capital cost and the unit net-taxes played a minor role. Though, it is remarkable that net operating surplus per unit of output as well as labour unit costs increased in the crisis period. Something similar applies again to the indirect effects. Contrary to the previous period, the labour unit costs contribute clearly most followed by the import unit costs.

Table 2: Drivers of German producer price inflation by industries (manufacturing and market services only)

			Manufacturing		Market services	
			2001-2008	2009-2014	2001-2008	2009-2014
		Producer Price Inflation (percent)	**1.60**	**0.92**	**1.00**	**1.19**
direct effects (equation 7)		Import Unit Costs	1.13	0.66	0.10	0.19
	Domestic Costs	Intermediate Input Unit Costs	0.54	-0.42	0.63	0.33
		Interm. Input Price	*0.70*	*0.46*	*0.47*	*0.43*
		Interm. Input Productivity	-0.16	-0.88	0.17	-0.10
		Labour Unit Costs	-0.25	0.45	0.07	0.93
		Labour Price	1.70	0.11	2.55	0.41
		Labour Productivity	-1.95	0.34	-2.48	0.52
		Unit Net Operating Surplus	0.20	0.16	0.06	-0.34
		Unit Consumption of fixed capital	-0.05	0.09	0.05	0.10
		Unit Taxes less Subsidies	0.03	-0.01	0.08	-0.02
		Total indirect effects (=Interm.Input Price)	*0.70*	*0.46*	*0.47*	*0.43*
indirect effects (equation 9)		Import Unit Costs	0.48	0.25	0.17	0.15
	Domestic Costs	Interm. Input Productivity	0.02	-0.22	0.09	-0.12
		Labour Unit Costs	-0.15	0.51	0.04	0.50
		Labour Price	1.63	0.18	1.41	0.22
		Labour Productivity	-1.79	0.33	-1.37	0.28
		Unit Net Operating Surplus	0.28	-0.20	0.05	-0.23
		Unit Consumption of fixed capital	0.04	0.13	0.07	0.14
		Unit Taxes less Subsidies	0.03	-0.01	0.05	-0.01

Note: Annual average inflation rates for the period 2001-2008 and 2009-2014 are reported. Inflation rates are a weighted average of the gross output price growth of 19 industries for manufacturing and 23 industries for market services (for details see Table A2 in the appendix). The shares of sectoral gross output in total gross output are used as weights.

In the pre crisis-period, for the *German market-service sector* the intermediate input unit costs were the most important driver while the labour unit costs contributed very little. Intermediate input price, rather than its productivity, is the major driver behind increasing intermediate input unit costs. Rising intermediate input prices were mainly driven by increasing import unit costs in the upstream sectors. The nearly unchanged unit labour costs can be explained by a labour price increase, which closely followed labour productivity gains pointing towards a productivity-oriented wage policy. The unit capital costs and the unit net-taxes contributed little in this period.

During the crisis the labour unit costs became the most important driver. The labour price slightly increased but labour productivity decreased resulting in an increase of the unit labour costs.

The unit net operating surplus decreased, offsetting partly the increase in unit labour costs. These change in the unit net operating surplus clearly reduced the inflation rate. The intermediate input unit costs remained an important driver and increased inflation, but to a lesser extent than in the previous period. Again, within the components of intermediate input unit costs the intermediate input prices are the main driver. The intermediate input prices, in turn, are mainly driven by labour unit costs of the upstream sectors. Compared to manufacturing the import unit costs are clearly less important for inflation in both periods.

Table 3 shows the annual average inflation differentials of the *manufacturing sector* vis-à-vis Germany for the countries in our sample in the period before the crisis 2000 to 2008. All inflation differentials were positive meaning that between 2000 and 2008 the manufacturing sectors of all countries lost competitiveness relative to German manufacturing. However, the degree of competitiveness loss varied and the countries can be grouped into three categories: The first group consisting of Greece, Estonia, Slovenia, Belgium and Netherlands exhibited high annual average inflation differentials lying above 1.5 percentage points. The second group comprising Italy and Portugal showed inflation differentials between 0.5 and 1 percentage points and the third including France and Austria had inflation differentials below 0.5 percentage points, with Austria's inflation differential being close to zero.

The drivers of inflation differentials across countries were quite heterogeneous. However, we can observe that for all countries labour unit costs in manufacturing grew faster than in Germany and were, though too different degrees, an important driver of inflation differentials in all countries. Also, in all countries except for Italy, import unit costs increased faster than in German manufacturing. Whereas for Estonia, France, Greece and Portugal faster growing direct labour unit costs than in Germany were the most important driver of inflation differentials, for Belgium, Netherlands and Slovenia faster growing import unit costs were the main driver.

Unit operating surplus tended to increase less than in Germany – only in Greek, Dutch and Slovenian manufacturing the surplus increased faster than in Germany – and inclined to reduce the inflation gap. Nearly half of the countries in the sample even showed an absolute decline in unit operating surplus of their manufacturing industries between 2000 and 2008 (Belgium, Estonia, Italy and France). Changes in unit operating surpluses relative to Germany were the most important driver of the inflation differential in Austria and substantially reduced the inflation gap vis-à-vis Germany.

We also observe that in all countries intermediate input prices were growing faster than in Germany. Accelerated growth of labour unit costs, relative to Germany, in the upstream sectors of the manufacturing industries were mainly responsible for this development. In the Italian manufacturing sector faster growing intermediate input prices than in Germany, due to faster rising labour unit costs in the upstream sectors (indirect labour unit costs), were the most important driver of the inflation differential. The increase in intermediate input prices relative to Germany was also a substantial contributor to the inflation differential in Estonia, Slovenia and Greece.

For many countries, the faster growing labour unit costs than in Germany, in the period 2000 to 2008 can rather be explained by the labour productivity gap of these countries relative to the

Table 3: Average producer price inflation differential relative to Germany in manufacturing sector by country, 2001-2008 (percentage point)

			AUT	BEL	EST	FRA	GRC	ITA	NLD	PRT	SVN
		Producer Price Inflation Differential	**0.02**	**1.70**	**2.34**	**0.27**	**2.60**	**0.90**	**1.51**	**0.57**	**1.87**
direct effects (equation 7)		Import Unit Costs	0.00	1.32	0.66	0.09	0.32	-0.32	1.62	0.09	0.94
	Domestic Costs	Intermediate Input Unit Costs	0.03	-0.20	0.52	0.09	0.78	0.86	-0.95	-0.08	-0.06
		Interm. Input Price	*0.01*	*0.09*	*1.22*	*0.16*	*0.85*	*0.71*	*0.05*	*0.22*	*1.01*
		Interm. Input Productivity	0.02	-0.29	-0.70	-0.07	-0.07	0.15	-1.01	-0.30	-1.07
		Labour Unit Costs	0.04	0.54	1.16	0.39	1.17	0.54	0.41	0.38	0.82
		Labour Price	-0.06	-0.23	1.25	-0.13	0.15	-0.22	-0.23	0.00	0.67
		Labour Productivity	0.10	0.78	-0.09	0.52	1.02	0.76	0.63	0.38	0.15
		Unit Net Operating Surplus	-0.15	-0.65	-0.43	-0.31	0.20	-0.42	0.14	-0.16	0.11
		Unit Consumption of fixed capital	0.13	0.68	0.33	NA	0.10	0.17	0.13	0.22	0.07
		Unit Taxes less Subsidies	-0.04	0.00	0.11	0.01	0.04	0.06	0.16	0.13	0.01
		Total indirect effects (=Interm. Input Price)	*0.01*	*0.09*	*1.22*	*0.16*	*0.85*	*0.71*	*0.05*	*0.22*	*1.01*
indirect effects (equation 9)		Import Unit Costs	-0.06	-0.05	0.34	-0.07	-0.09	-0.02	-0.07	-0.07	0.36
	Domestic Costs	Interm. Input Productivity	0.16	-0.20	-0.34	0.09	0.06	0.09	-0.25	0.00	-0.34
		Labour Unit Costs	0.11	0.45	0.96	0.47	1.06	0.79	0.43	0.44	0.85
		Labour Price	-0.38	-0.35	0.71	0.48	0.69	0.50	-0.25	0.08	0.29
		Labour Productivity	0.49	0.80	0.26	-0.01	0.36	0.29	0.68	0.35	0.55
		Unit Net Operating Surplus	-0.13	-0.36	-0.07	-0.27	-0.19	-0.43	-0.15	-0.27	0.16
		Unit Consumption of fixed capital	0.00	0.28	0.34	NA	0.00	0.20	0.06	0.11	-0.01
		Unit Taxes less Subsidies	-0.07	-0.04	-0.01	-0.06	0.02	0.07	0.02	0.01	-0.01

Note: Differences in annual average inflation rates for the period 2001-2008 are reported. Inflation rates are a weighted average of the gross output price growth of 19 manufacturing industries (for details see Table A2 in the appendix). The shares of sectoral gross output in total gross output are used as weights. Country codes see Table A1 in the appendix. For France (FRA) the contribution of Unit Consumption of fixed capital is included in Unit Net Operating Surplus.

German manufacturing sector than accelerated growth of labour prices – the former transition countries Estonia and Slovenia are an exception. The manufacturing sectors of all countries, except for Estonia, exhibited a lower labour productivity growth than the German manufacturing sector. The gap in labour productivity growth relative to Germany was especially high in Greece, Belgium, Italy and Netherlands (above 0.5 percentage points). The gap was less pronounced in Portugal, France, Slovenia and Austria (below 0.5 percentage points). The labour price decreased relative to Germany in the Netherlands, Belgium, Italy and Austria and contributed towards lowering the inflation differentials of these countries. Despite lower labour productivity growth in Greece, France and Slovenia relative to Germany, labour prices in these countries grew even faster than in Germany and further raised the gap in labour unit costs as well as the inflation differential of those countries.

Table 4 shows that in the period during the crisis 2009 to 2014 annual average inflation differentials in the *manufacturing sector* decreased relative to the pre-crisis period, except for Austria, but inflation differentials remained positive for most of the countries. Therefore, the manufacturing sectors of most countries in the sample continued to lose price competitiveness during the crisis relative to Germany. Portugal, and to a lesser extent Italy, were exceptions from this trend, gaining price competitiveness relative to Germany. The French producer price inflation in the manufacturing sector was close to the German inflation rate in the period 2009 to 2014.

However, the drivers of inflation differentials in the crisis period differed from the drivers in the pre-crisis period. Changes in labour unit costs relative to Germany tended to play a less important role in the crisis-period and the evolution of intermediate input unit costs, followed by changes in import unit costs became the most important drivers of inflation differentials during the crisis.

Intermediate input unit costs increased in all countries relative to Germany and were an important driver of inflation differentials in the manufacturing sector for all countries during the crisis. Increases in intermediate input unit costs were the most important driver of inflation differentials in Austria, Estonia, France, Greece, Netherlands and Slovenia. The increases in intermediate input unit costs relative to Germany can rather be attributed to lower (intermediate input) productivity growth rates than overproportional jumps in (intermediate input) prices.

Though, the contribution of rising intermediate input prices to unit cost increases was non-negligible in Estonia and Italy. The indirect effects indicate that increasing prices for intermediate inputs in the Estonian manufacturing sector were mainly driven by rising operating surplus in the upstream sectors of the manufacturing industries. In absolute terms, all countries experienced productivity gains in the usage of intermediate inputs with Germany leading the way. Only the Greek manufacturing sector showed a substantial downturn in intermediate input productivity.

As in the pre-crisis period, import unit costs of the Belgian and Dutch manufacturing sector increased substantially faster than in the German manufacturing sector between 2009 and 2014 and constituted the main driver of the inflation differential in both periods. Also, in Estonia import unit costs accelerated essentially faster than in Germany.

Table 4: Average producer price inflation differential relative to Germany in manufacturing sector by country, 2009-2014 (percentage point)

		AUT	BEL	EST	FRA	GRC	ITA	NLD	PRT	SVN
	Producer Price Inflation Differential	**0.13**	**0.51**	**0.64**	**-0.02**	**0.58**	**-0.13**	**0.24**	**-0.61**	**0.15**
direct effects (equation 7)	Import Unit Costs	0.06	1.30	0.36	-0.14	0.05	0.02	1.18	-0.12	-0.13
Domestic Costs	Intermediate Input Unit Costs	0.55	0.32	0.69	0.55	1.39	0.55	0.53	0.23	0.38
	Interm. Input Price	*-0.06*	*0.08*	*0.29*	*-0.03*	*-0.01*	*0.20*	*-0.23*	*-0.31*	*-0.21*
	Interm. Input Productivity	0.61	0.24	0.39	0.57	1.40	0.35	0.76	0.54	0.60
	Labour Unit Costs	-0.20	-0.32	-0.39	-0.12	-0.55	-0.03	-0.34	-0.61	-0.07
	Labour Price	0.03	-0.01	0.55	0.15	-0.75	0.07	-0.15	-0.28	0.08
	Labour Productivity	-0.24	-0.31	-0.94	-0.28	0.20	-0.10	-0.19	-0.33	-0.15
	Unit Net Operating Surplus	-0.45	-0.22	-0.05	-0.33	-0.30	-0.58	-0.42	-0.01	-0.11
	Unit Consumption of fixed capital	0.14	-0.04	0.01	NA	-0.01	0.21	-0.04	-0.09	0.10
	Unit Taxes less Subsidies	0.04	-0.53	0.03	0.02	0.00	-0.30	-0.67	0.00	-0.02
	Total indirect effects (=Interm. Input Price)	*-0.06*	*0.08*	*0.29*	*-0.03*	*-0.01*	*0.20*	*-0.23*	*-0.31*	*-0.21*
indirect effects (equation 9)	Import Unit Costs	-0.02	0.26	0.06	0.03	-0.27	0.05	-0.09	-0.09	-0.08
Domestic Costs	Interm. Input Productivity	0.07	0.03	0.08	0.06	0.32	0.13	0.27	-0.10	0.16
	Labour Unit Costs	-0.16	-0.27	-0.49	-0.10	-0.29	0.13	-0.41	-0.57	-0.32
	Labour Price	-0.02	-0.17	-0.03	-0.03	-0.83	-0.11	-0.22	-0.45	-0.32
	Labour Productivity	-0.14	-0.10	-0.46	-0.07	0.54	0.24	-0.19	-0.12	0.00
	Unit Net Operating Surplus	-0.03	0.29	0.62	-0.07	0.32	-0.12	0.23	0.48	-0.01
	Unit Consumption of fixed capital	0.03	-0.09	-0.01	NA	-0.07	0.20	-0.08	-0.07	-0.01
	Unit Taxes less Subsidies	0.05	-0.13	0.03	0.06	-0.02	-0.20	-0.16	0.05	0.06

Note: Differences in annual average inflation rates for the period 2009-2014 are reported. Inflation rates are a weighted average of the gross output price growth of 19 manufacturing industries (for details see Table A2 in the appendix). The shares of sectoral gross output in total gross output are used as weights. Country codes see Table A1 in the appendix. For France (FRA) the contribution of Unit Consumption of fixed capital is included in Unit Net Operating Surplus.

First, we recognize that contrary to the pre-crisis period changes in labour unit costs only played a minor role in driving the manufacturing price inflation differentials between Germany and the other countries in the sample. Notably, Portugal, Greece and to a lesser extent Estonia and Belgium were the exceptions. A strong relative or even absolute decline in labour unit costs in those countries substantially contributed to dampen the inflation differential vis-à-vis Germany. Second, and contrary to the pre-crisis period, all countries showed a decrease in labour unit costs relative to Germany. The decline was most pronounced in Portugal and Greece, which were the only countries exhibiting an absolute decline in labour unit costs. For all other countries labour unit costs increased, but less strongly than in Germany. This trend was mainly driven by labour productivity growth rates of the other European countries exceeding that of Germany. Where Greece is the exception – labour unit costs closely follow the path of strong labour price cuts. Also, in Portugal, declining labour prices contributed substantially to decelerating labour unit costs.

Analysing the evolution of the unit net operating surplus in manufacturing reveals that the trend of declining operating surplus relative to Germany in the first period continued in the second period. Relative declines in unit operating surpluses for most countries dampened the inflation differential of these countries versus Germany. Note, that absolute declines in profitability are observable in the Austrian, Belgian, French, Greek, Italian and Dutch manufacturing sectors, whereas Italy's and Belgium's profitability not only decreased during the crisis but also in the pre-crisis period. The decrease in unit operating surplus relative to Germany was especially pronounced in Italy, where it was the most important driver of the inflation differential allowing the Italian manufacturing sector to gain price competitiveness versus all countries in the sample, except versus Portugal.

Table 5 shows the results for *market services* in the pre-crisis period 2000 to 2008. For all countries the inflation differential in the market service sector was positive in these sectors. As a consequence, market service sectors of all countries lost competitiveness vis-à-vis Germany. Estonia and Slovenia showed particularly high values (above 4.5 percentage points). These two countries are former transition countries that prepared to join the European Single Market by 2004, later they prepared for entry into the European Monetary Union. Particularly, medium- sized inflation differentials (between 0.69 and 1.11 percentage points) could be observed for Austria, Belgium, France, and the Netherlands. All of these countries had been members of the European Single Market for many years and maintained close trade relations with Germany. The remaining countries showing inflation differentials above 1.33 percentage points are Greece, Italy and Portugal.

Increasing labour unit costs were the main driver in all countries. Unit labour costs rose faster than in Germany and thus increased the inflation differentials. This is particularly pronounced in Estonia, Slovenia and Greece. For almost all countries this development can be explained mainly by an increasing labour price gap relative to Germany. Again, this is particularly pronounced in Estonia, Slovenia and Greece. Despite increasing labour prices relative to Germany labour productivity decreased relative to Germany in some countries (such as Belgium, Greece, Italy, Portugal and Slovenia) and contributed towards a further widening of the unit labour cost gap. By contrast, in some other countries (such as in Austria, Estonia France and the Netherlands)

Table 5: Average producer price inflation differential relative to Germany in market services, 2001-2008 (percentage point)

			AUT	BEL	EST	FRA	GRC	ITA	NLD	PRT	SVN
		Producer Price Inflation Differential	**0.74**	**1.11**	**4.57**	**0.69**	**1.98**	**1.59**	**1.04**	**1.33**	**5.54**
direct effects (equation 7)		Import Unit Costs	0.18	0.30	0.87	0.05	0.26	0.03	0.27	0.04	0.73
	Domestic Costs	Intermediate Input Unit Costs	0.13	0.01	1.11	0.24	0.27	0.59	-0.15	0.22	1.58
		Interm. Input Price	*0.10*	*0.41*	*1.61*	*0.23*	*0.73*	*0.68*	*0.26*	*0.48*	*1.69*
		Interm. Input Productivity	0.03	-0.40	-0.50	0.00	-0.46	-0.08	-0.41	-0.26	-0.12
		Labour Unit Costs	0.28	0.58	1.70	0.48	1.48	0.92	0.62	0.72	2.37
		Labour Price	0.43	0.35	2.22	0.64	1.26	0.20	0.66	0.32	1.40
		Labour Productivity	-0.15	0.23	-0.53	-0.16	0.22	0.71	-0.04	0.40	0.96
		Unit Net Operating Surplus	0.15	-0.25	0.25	0.00	0.00	-0.18	0.24	0.23	0.70
		Unit Consumption of fixed capital	0.02	0.58	0.60	NA	-0.01	0.17	0.08	0.12	0.12
		Unit Taxes less Subsidies	-0.02	-0.10	0.04	-0.06	-0.02	0.06	-0.01	-0.01	0.05
		Total indirect effects (=Interm. Input Price)	*0.10*	*0.41*	*1.61*	*0.23*	*0.73*	*0.68*	*0.26*	*0.48*	*1.69*
indirect effects (equation 9)		Import Unit Costs	0.06	0.24	0.55	0.04	0.01	0.08	0.10	0.09	0.44
	Domestic Costs	Interm. Input Productivity	0.07	-0.12	-0.32	-0.02	-0.21	-0.04	-0.27	-0.10	-0.20
		Labour Unit Costs	0.00	0.28	0.79	0.25	0.63	0.52	0.32	0.30	1.02
		Labour Price	0.00	0.35	1.17	0.60	0.27	0.19	0.18	0.26	0.78
		Labour Productivity	0.00	-0.07	-0.38	-0.35	0.36	0.33	0.15	0.04	0.23
		Unit Net Operating Surplus	0.01	-0.36	0.27	0.00	0.37	-0.04	0.06	0.12	0.45
		Unit Consumption of fixed capital	0.00	0.42	0.29	NA	-0.04	0.13	0.06	0.09	-0.01
		Unit Taxes less Subsidies	-0.05	-0.05	0.04	-0.04	-0.03	0.02	-0.01	0.00	0.00

Note: Differences in annual average inflation rates for the period 2001-2008 are reported. Inflation rates are a weighted average of the gross output price growth of 23 market service industries (for details see Table A2 in the appendix). The shares of sectoral gross output in total gross output are used as weights. Country codes see Table A1 in the appendix. For France (FRA) the contribution of Unit Consumption of fixed capital is included in Unit Net Operating Surplus.

labour productivity increased slightly faster than in Germany, which had a dampening effect on the labour unit cost gaps and thus on inflation differentials.

The intermediate input unit cost developments contributed in all countries (except in the Netherlands) towards increasing the inflation differentials. In some countries (such as Estonia, France, Greece and Slovenia) the intermediate input costs even proved to be the second most important driver. Among the two subcomponents (i.e., price and productivity) the price component (considered as indirect effects) turned out to be stronger. In all countries, intermediate input prices increased faster than in Germany, raised intermediate input costs and enhanced inflation differentials. The increase was particularly high in Estonia and Slovenia with more than 1.4 percentage points, particularly low in Austria, France and the Netherlands with below 0.3 percentage points and medium-sized in Belgium, Greece, Italy and Portugal with values between 0.4 and 0.7 percentage points. The main driver of the intermediate input price gap vis-à-vis Germany was a stronger rise in labour unit costs in the upstream sectors caused by an accelerated growth of labour prices in most countries. In all countries (except for Austria and France), intermediate input productivity grew faster than in Germany, which decreased the intermediate input unit cost differentials and consequently the inflation differentials.

The import unit costs increased in all countries relative to Germany, and the unit capital costs (unit net operating surplus plus unit consumption of fixed capital) also enlarged the differentials in many countries, but to a lesser extent. The unit taxes less subsidies were virtually negligible throughout all countries. In some countries they slightly increased, while in other countries they slightly decreased the differentials.

Table 6 shows that during the crisis 2009 to 2014 the differentials in *market services* were consistently lower than before the crisis. For the majority of the countries the differentials were still positive indicating a further loss of competitiveness. Countries that considerably lost competitiveness are Belgium and Estonia. Countries that lost some of their competitiveness are Austria, Italy and the Netherlands. A few countries, however, showed negative inflation differentials indicting a gain in competitiveness vis-à-vis Germany during the crisis period. Portugal, France, Greece and Slovenia belong to this group. Portugal caught up particularly well. A closer look at the drivers of this development reveals that in the Portuguese market service sector, labour price and intermediate input price increased less and intermediate input productivity increased faster than in Germany.

In the crisis period, the labour unit costs lost its importance as drivers for many countries whereas changes in unit operating surplus and intermediate input unit costs became more important. Nevertheless, labour costs remained most important for Greece, Portugal, and Slovenia. Unlike the previous period, the labour costs reduced the differentials vis-à-vis the German market service sector for all countries. For most countries this is due to a lower price increase compared to Germany. The only exception is Estonia. The improvement was particularly pronounced in Greece, Portugal and Slovenia. Greece, Slovenia, Portugal, Italy and the Netherlands do not only exhibit a decline in labour prices relative to Germany but also an absolute downturn in the hourly price of labour. With respect to labour productivity the picture is mixed. In many countries the

Table 6: Average producer price inflation differential relative to Germany in market services, 2009-2014 (percentage point)

		AUT	BEL	EST	FRA	GRC	ITA	NLD	PRT	SVN
	Producer Price Inflation Differential	**0.46**	**0.81**	**1.61**	**-0.43**	**-0.71**	**0.42**	**0.32**	**-1.22**	**-0.42**
direct effects (equation 7)	Import Unit Costs	0.10	0.59	0.46	0.20	-0.12	0.01	0.23	-0.11	0.01
Domestic Costs	Intermediate Input Unit Costs	0.13	-0.10	0.63	-0.30	0.23	0.29	-0.18	-0.66	0.06
	Interm. Input Price	*0.15*	*0.31*	*0.51*	*-0.03*	*-0.49*	*0.23*	*0.00*	*-0.42*	*-0.22*
	Interm. Input Productivity	-0.01	-0.41	0.13	-0.27	0.72	0.06	-0.18	-0.24	0.28
	Labour Unit Costs	-0.07	-0.28	-0.47	-0.26	-0.49	-0.09	-0.58	-0.72	-0.57
	Labour Price	-0.02	-0.34	0.09	-0.23	-1.76	-0.45	-0.55	-0.92	-1.16
	Labour Productivity	-0.04	0.06	-0.56	-0.03	1.27	0.36	-0.03	0.20	0.59
	Unit Net Operating Surplus	0.06	0.71	0.66	-0.21	-0.31	0.11	1.06	0.16	-0.13
	Unit Consumption of fixed capital	0.11	0.06	0.18	NA	-0.03	0.10	-0.01	0.03	0.04
	Unit Taxes less Subsidies	0.14	-0.17	0.15	0.14	0.01	0.00	-0.20	0.07	0.16
	Total indirect effects (=Interm. Input Price)	*0.15*	*0.31*	*0.51*	*-0.03*	*-0.49*	*0.23*	*0.00*	*-0.42*	*-0.22*
indirect effects (equation 9)	Import Unit Costs	0.09	0.34	0.16	0.09	-0.12	0.00	0.11	-0.05	-0.01
Domestic Costs	Interm. Input Productivity	0.01	-0.16	0.03	-0.02	0.18	0.13	0.11	-0.08	0.09
	Labour Unit Costs	-0.08	-0.17	-0.30	-0.10	-0.35	0.03	-0.38	-0.38	-0.29
	Labour Price	-0.03	-0.26	0.03	-0.11	-0.72	-0.22	-0.30	-0.54	-0.56
	Labour Productivity	-0.06	0.09	-0.33	0.02	0.36	0.25	-0.09	0.16	0.27
	Unit Net Operating Surplus	0.03	0.48	0.54	-0.10	-0.11	0.02	0.35	0.08	-0.11
	Unit Consumption of fixed capital	0.04	-0.07	0.03	NA	-0.10	0.11	-0.08	-0.06	0.03
	Unit Taxes less Subsidies	0.07	-0.11	0.05	0.11	0.00	-0.05	-0.10	0.07	0.07

Note: Differences in annual average inflation rates for the period 2009-2014 are reported. Inflation rates are a weighted average of the gross output price growth of 23 market service industries (for details see Table A2 in the appendix). The shares of sectoral gross output in total gross output are used as weights. Country codes see Table A1 in the appendix. For France (FRA) the contribution of Unit Consumption of fixed capital is included in Unit Net Operating Surplus.

productivity developments lags behind Germany, causing labour unit costs to increase relative to Germany. In some countries (such as in Estonia and to a minor extent in Austria, France, and the Netherlands), by contrast, the labour productivity increased more than in Germany which lowers the labour unit costs differentials and consequently the inflation differentials.

Interestingly, and contrary to tendencies observable in the manufacturing sector, the unit net operating surplus increased the differential for many countries. That is profitability was growing at a faster rate than in the German market service sector. It contributed most in some countries (such as in Belgium, Estonia and the Netherlands). Only in France, Greece and Slovenia the development of the operating surplus caused a reduction of the inflation differentials.

The intermediate input unit costs components were the most important driver of inflation differentials for France and Italy. For Estonia and Portugal, it was the second most important driver. The effect, however, was mixed. For some countries, intermediate input unit costs reduced (particularly for Portugal, France) and for others (particularly for Estonia and Italy) increased the differential. Within this category the intermediate input price contributes more than the intermediate input productivity in six out of twelve countries.

Again, the contribution is mixed. It increased (such as for Belgium and Estonia) or decreased (such as for Greece and Portugal) the differentials. A closer look at the drivers of the intermediate input prices reveals a heterogenous picture. Not only the unit labour costs of the upstream sectors but also the operating surpluses play an important role. While operating surpluses tended to increase intermediate input prices relative to Germany, unit labour costs developments tended to have a dampening effect on the differentials.

The effects of the import unit costs are diverse. In some countries they slightly increased, while in other countries they slightly decreased the differentials. But for most countries (with the exception of Belgium and the Netherlands) it was almost negligible. The contributions of the unit consumption of fixed capital are for all countries negligible. The unit taxes less subsidies were for some countries clearly more important drivers than in the pre-crisis period. In all countries except in Belgium and the Netherlands it increased the differentials.

VI. Conclusions

In this paper we introduce a price analysis approach based on Leontief input output price models and structural decomposition analysis (SDA). A comprehensive decomposition procedure enables us to reveal the drivers of producer price inflation. While not immediately revealing causal relationships the SDA based approach produces a decomposition that is "true" in the sense of an accounting relationship. We apply the suggested model to analyse producer price inflation differentials relative to Germany for a representative sample of member states of the EMU against the background of diverging trends in competitiveness across European countries after the introduction of the Euro (cf. Pancotto and Pericoli, 2014). The countries covered in our sample are Austria, Belgium, Estonia, Germany, France, Greece, Italy, Netherlands, Portugal and Slovenia. The sample period covers the years 2000 to 2014 and the data basis consists of a time series of World Input Output tables enlarged by detailed Social Economic Accounts taken from the World Input Output Database and Eurostat.

Inflation differentials are at the heart of the discussion about the evolution of major macroeconomic imbalances (e.g. current account imbalances) within the euro zone, which ultimately led to the European sovereign debt crisis (for a review of this debate see Johnston and Regan, 2016; Nölke, 2016; Höpner and Lutter, 2018). The competitiveness debate largely focuses on direct nominal unit labour cost developments - sometimes at the level of the overall economy sometimes on industry-level - before the crisis and assumes a strong correlation with price inflation. The inflation differential literature surveyed by de Haan (2010) focuses on consumer price inflation and the period before the financial crisis. As discussed in section I and II direct unit labour costs and consumer price indices are unsatisfactory measures for analysing changes in price competitiveness since both suffer from incomplete coverage of production costs and misleading coverage of sectors in the case of consumer prices. This article contributes to the inflation differential literature and the competitiveness debate in several ways:

First, our approach allows to trace back producer price inflation differentials to different developments not only in i) labour unit costs but also in ii) domestic intermediate input unit costs, iii) imported intermediate input unit costs, iv) unit net operating surpluses, v) unit consumption of fixed capital and vi) unit taxes less subsidies. Furthermore, labour unit costs and intermediate input unit costs are each decomposed into a productivity and a price component. Second, we evaluate inflation differentials at the sectoral level and hence, exactly for those industries which are mostly exposed to international competition, i.e. the manufacturing and the market service sector. Third, the input-output framework allows us to assess how the different unit cost developments in the upstream sectors of the manufacturing and market service industries contributed to the evolution of competitiveness gaps. In this way our approach accounts for the indirect effects originating from the interdependences between sectors in an economy. This is meaningful since a sector may benefit from e.g. low wages in upstream sectors. Fourth, we extend the analysis of inflation differentials to the period after the financial crisis (2009-2014).

In our empirical analysis we find that the manufacturing and market service sectors of all countries in the sample lost price competitiveness vis-à-vis Germany in the pre-crisis period (2000-2008). Among the funding members of the EMU particularly large and persistent inflation differentials are revealed for Greece, Portugal and Italy, but also for Belgium and the Netherlands. Interestingly, the manufacturing and market service sectors of many countries continued to lose price competitiveness vis-à-vis Germany, though to a lesser extent, also during the crisis period (2009-2014), including the Greek manufacturing and the Italian market service sector.

The drivers of inflation differentials across countries are quite heterogeneous. Though, we observe that differences in unit labour cost developments across European countries constitute an important driver of producer price inflations differentials, especially in the period before the crisis (2000-2008), both in the manufacturing and the market services sector. In the pre-crises period in both sectors and for all countries labour unit costs increased faster than in Germany contributing positively to the inflation differentials. The opposite can be observed in the crisis period, where labour unit cost developments dampened the inflation gaps vis-à-vis Germany. These trends are noticeable in both direct and indirect effects; see e.g. Italian manufacturing in the pre-crisis period, where intermediate input price increases are an important driver of the inflation differential and are strongly determined by labour unit cost increases in its upstream sectors.

To highlight the importance of industry-level analysis, we notice the heterogeneous drivers behind the labour unit cost differentials vis-á-vis Germany and the opposite trends of relative profitability in the manufacturing and the market services sector. While, for most countries, the unit labour cost gap evolving during the pre-crisis period in the manufacturing sector is due to lagging behind the German labour productivity growth rates (in line with e.g. Pancotto and Pericoli, 2014) the unit labour cost gap in the market service sector can be largely traced back to faster labour price increases than in Germany. We also find that the profitability (net operating surplus) of the manufacturing sector of most countries tended to decrease relative to Germany in both periods but the profitability in the market service sectors tended to increase.

Other drivers are not negligible and are of particular importance during the crisis period (2009-2014). Considering the *manufacturing sector* in the pre-crisis period for some countries the development of import unit costs (Belgium, the Netherlands and Slovenia), the evolution of intermediate input unit costs (Italy) and the development of unit operating surpluses (Austria) are the most important drivers, whereas in the crisis period the evolution of intermediate input prices and productivities and changes in import unit costs became the most relevant drivers (except Italy and Portugal). In the *market services* in the pre-crisis period for all countries the evolution of labour unit costs was actually the most important driver whereas in the crisis period changes in unit operating surplus and intermediate input unit costs became more important.

Against the background of the above-mentioned developments and their driving factors, the question arises how economic policy could influence the inflation differentials. Given the major importance of the evolution of labour unit costs for the development of producer price inflation differentials (particularly in the non-crisis period) a coordinated EMU-wide wage policy with the common principle of productivity-oriented wage agreements could be helpful. Deviations from this principle by individual member states should be avoided. To preserve or improve external competitiveness vis-á-vis trading partners outside the EU a coordinated deflation of unit labour costs or a devaluation of the common currency would still be a possible policy choice. However, it is questionable how this can be implemented in the current, highly fragmented European labour markets with strong national heterogeneity (for a detailed discussion of these issues see e.g. Höpner and Lutter, 2018). Moreover, for countries and sectors where increasing profits drive the inflation differential an effective competition policy to limit market power in oligopolies could be a meaningful option.

This study reveals the main drivers of the inflation differentials in selected member states of the European Union. Detailed policy-oriented analyses are outside of the scope of this study. Departing from this point further research is needed to explore the deeper reasons behind the drivers and establish causal links. For example, it would be relevant to investigate in greater detail what causes the different developments of the main drivers (such as labour costs) including the impact of economic policy variables and institutional frameworks (an example therefore is Höpner and Lutter, 2018). Additionally, in depth individual country and sectoral analysis due to remarkable heterogeneity found in this study seems to be useful (e.g. comparative studies could take the work of Dustmann et al., 2014 as starting point).

References

Aldasoro, J.I., and V. Žďárek, "Inflation Differentials in the Euro Area and their Determinants – an empirical view," *William Davidson Institute Working Paper* Number 958, April 2009 (https://deepblue.lib.umich.edu/bitstream/handle/2027.42/64425/wp958.pdf?sequence=1)

Altissimo, F., P. Benigno, and D. R. Palenzuela "Long-run determinants of inflation differentials in a Monetary Union," *NBER Working Paper* No. 11473, 2005. (https:// www.nber.org/papers/w11473)

Andersson, M., K. Masuch, and M. Schiffbauer, "Determinants of inflation and price level differentials across the Euro area countries," *ECB Working Paper* Series No. 1129, 2009 (http://ssrn.com/abstract_id=1519943)

Angeloni, I. and M. Ehrmann "Euro area inflation differentials," *The B.E. Journal of Macroeconomics*, 7 (1), 1935-1690, 2007.

Beck, G., K. Hubrich, and M. Marcellino, "Regional inflation dynamics within and across euro area countries and a comparison with the United States," *Economic Policy*, 24(57), 141 – 184, 2009.

Bennet, T.L., "The Theory of Measurement of Changes in Cost of Living," *Journal of the Royal Statistical Society*, 83, 455—462, 1920.

Busetti, F., L. Forni, A. Harvey, and F. Venditti, "Inflation Convergence and Divergence Within the European Monetary Union," *International Journal of Central Banking*, 3(2), 95 – 121, 2007.

De Boer, S. and H. K. van Tuinen, "Price Analysis and a System of Price Statistics," *Review of Income and Wealth*, 25(1), 41-63, 1979.

De Haan, J., "Inflation Differentials in the Euro Area: A Survey," In: De Haan J., Berger H. (eds) *The European Central Bank at Ten*. Springer, Berlin, Heidelberg, 11-32, 2010.

Donkers, H. W. J., "Methodology and Application of Price Analysis," *De Economist*, 130(3), 336-359, 1982.

Donkers, H. W. J. and A. C. van der Zwan, "Analysing consumer price changes by using input-output tables," *Statistical Journal of the United Nations Economic Commission for Europe*, 4(2), 195-211, 1986.

Dustmann, C., B. Fitzenberger, U. Schönberg, and A. Spitz-Oener, "From Sick Man of Europe to Economic Superstar: Germany's Resurgent Economy," *Journal of Economic Perspectives*, 28(1), 167-188, 2014.

ECB, "Inflation Differentials in the Euro Area: Potential Causes and Policy implications," *European Central Bank*, Frankfurt am Main, 2003. (https://www.ecb.europa.eu/pub/pdf/other/inflationdifferentialreporten.pdf)

ECB, "Monetary policy and inflation differentials in a heterogeneous currency area," European *Central Bank Monthly Bulletin*, Frankfurt am Main, pp. 61 – 77, May 2005. (https://www.ecb.europa.eu/pub/pdf/mobu/mb200505en.pdf)

ECB, "Inflation Differentials in the Euro Area: Potential Causes and Policy implications," *European Central Bank Monthly Bulletin*, Frankfurt am Main, pp. 52 – 55, December 2006. (https://www.ecb.europa.eu/pub/pdf/mobu/mb200612en.pdf)

ECB, "Judging sectoral inflation developments," *European Central Bank Monthly Bulletin*, Frankfurt am Main, pp. 48 – 50, May 2008. (https://www.ecb.europa.eu/pub/pdf/mobu/mb200805en.pdf)

Egert, B., "Real convergence, Price level, Convergence and Inflation Differentials in Europe," *CESIFO Working Paper* No. 2127, 2007 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1022513)

Fischer, C., O. Hossfeld, and K. Radeck "On the Suitability of Alternative Competitiveness Indicators for Explaining Real Exports of Advanced Economies," *Open Economic Review,* 29, 119–139, 2018.

Fujikawa, K., H. Izumi, and C. Milana, "A Comparison of Cost Structures in Japan and the U.S. Using Input-Output Tables," *Journal of Applied Input-Output Analysis*, 2(2), 1–23, 1995.

Fujikawa, K., and C. Milana, "Input-Output Decomposition Analysis of Sectoral Price Gaps between Japan and China," *Economic Systems Research*, 14(1), 59-79, 2002.

Griliches, Z., "The Discovery of the Residual: A Historical Note," *Journal of Economic Literature*, 34, 1324–1330, 1996.

Hofmann, B. and H. Remsperger, "Inflation differentials among the Euro area countries: Potential causes and consequences," *Journal of Asian Economics* 16 (3), 403-419, 2005.

Honohan, P. and P.R. Lane, "Divergent Inflation Rates in EMU," *Economic Policy*, 18(37), 357–394, 2003.

Höpner, M. and M. Lutter, "The diversity of wage regimes: Why the Eurozone is too heterogenous for the Euro," *European Political Science Review*, 10(1), 71-96, 2018.

Hsieh, C.T., "What explains the Industrial Revolution in East Asia? Evidence From the Factor Markets," *American Economic Review*, 92, 502–526, 2002.

Hulten, C.R., "Growth Accounting," in B. Hall and N. Rosenberg, ed., *Handbook of the Economics of Innovation*, Volume 2, 987–1031, North-Holland, Amsterdam, 2010.

Inklaar, R. and M. P. Timmer, "The Relative price of Services," *The Review of Income and Wealth,* 60(4), 727–746, 2014.

Jorgenson, D.W. and Z. Griliches, "The Explanation of Productivity Change," *Review of Economic Studies*, 34, 249–283, 1967.

Johnston, A. and A. Regan, "European Monetary Integration and the Incompatibility of National Varieties of Capitalism," *Journal of Common Market Studies*, 54(2), 318–336, 2016.

Lagoa, S., "Determinants of inflation differentials in the euro area: Is the New Keynesian Phillips Curve enough?" *Journal of Applied Economics*, 20(1), 75–103, 2017.

Leontief, W., *The Structure of American Economy, 1919–1939*, Oxford University Press, New York, 1951.

Marczewski, J., "Inflation, Redistribution of factors and unemployment: illustrated by the case of France," *Review of Income and Wealth,* 24(3), 283-311, 1978.

McCombie, J.S.L., "The Solow Residual, Technical Change, and Aggregate Production Functions," *Journal of Post Keynesian Economics*, 23, 267–297, 2000.

Meyler, A., "Profit margins in the Euro Area: A macroeconomic perspective," mimeo, Central Bank of Ireland, 2001.

Nölke, A., "Economic causes of the Eurozone crisis: the analytical contribution of Comparative Capitalism", *Socio-Economic Review*, 14(1), 141–161, 2016.

Nordhaus, W.D. and J.B. Showen, "A Technique for Analysing and Decomposing Inflation," in: Popkin, J (ed.), *The Analysis of Inflation: 1965-1974*, National Bureau of Statistics, 333 – 360, 1977. (https://www.nber.org/chapters/c0996.pdf)

Pancotto, F. and F.M. Pericoli, "Till labor cost do us part. On the long run convergence of EMU countries," *International Economics and Economic Policy*, 11, 371–395, 2014.

Rose, A. and S. Casler, "Input-output structural decomposition analysis: A critical appraisal," *Economic Systems Research*, 8, 33–62, 1995.

Solow, R.M., "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics*, 39, 312–320, 1957.

Storm, S. and C.W.M Naastepad, "Europe's Hunger Games: Income Distribution, Cost Competitiveness and Crisis," *Cambridge Journal of Economics*, 39(3), 959–986, 2015.

Timmer, M. P., E. Dietzenbacher, B. Los, R. Stehrer, and G. J. de Vries, "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production," *Review of International Economics*, 23, 575–605, 2015.

Timmer, M. P., B. Los, R. Stehrer, and G. J. de Vries, "An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release," *GGDC research memorandum* number 162, University of Groningen, 2016. (https://www.rug.nl/ggdc/html_publications/memorandum/gd162.pdf)

Trivedi, P.K, "Some Discrete Approximations to Divisia Integral Indices," *International Economic Review*, 22, 71–77, 1981.

Wyplosz, C., "The Eurozone Crisis and the Competitiveness Legend," *Asian Economic Papers*, 12(3), 63-81, 2013.

Appendix

Table A1: List of Countries and its membership in European Single Market (ESM) and European Monetary Union (EMU)

Country	Country Code	accession to the ESM	accession to the EMU
Austria	AUT	1 January 1995	1 January 1999
Belgium	BEL	1 January 1993	1 January 1999
Germany	DEU	1 January 1993	1 January 1999
Estonia	EST	1 May 2004	1 January 2011
France	FRA	1 January 1993	1 January 1999
Greece	GRC	1 January 1993	1 January 2001
Italy	ITA	1 January 1993	1 January 1999
Netherlands	NLD	1 January 1993	1 January 1999
Portugal	PRT	1 January 1993	1 January 1999
Slovenia	SVN	1 May 2004	1 January 2007

Table A2: List of Industries, Sector Classification, and Sector Groups

Industry	Industry Code	Sector
Crop and animal production, hunting and related service activities	A01	Other sectors
Forestry and logging	A02	Other sectors
Fishing and aquaculture	A03	Other sectors
Mining and quarrying	B	Other sectors
Manufacture of food products, beverages and tobacco products	C10-C12	Manufacturing
Manufacture of textiles, wearing apparel and leather products	C13-C15	Manufacturing
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C16	Manufacturing
Manufacture of paper and paper products	C17	Manufacturing
Printing and reproduction of recorded media	C18	Manufacturing
Manufacture of coke and refined petroleum products	C19	Manufacturing
Manufacture of chemicals and chemical products	C20	Manufacturing
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21	Manufacturing
Manufacture of rubber and plastic products	C22	Manufacturing
Manufacture of other non-metallic mineral products	C23	Manufacturing
Manufacture of basic metals	C24	Manufacturing
Manufacture of fabricated metal products, except machinery and equipment	C25	Manufacturing
Manufacture of computer, electronic and optical products	C26	Manufacturing
Manufacture of electrical equipment	C27	Manufacturing
Manufacture of machinery and equipment n.e.c.	C28	Manufacturing
Manufacture of motor vehicles, trailers and semi-trailers	C29	Manufacturing
Manufacture of other transport equipment	C30	Manufacturing
Manufacture of furniture; other manufacturing	C31_C32	Manufacturing
Repair and installation of machinery and equipment	C33	Manufacturing
Electricity, gas, steam and air conditioning supply	D35	Other sectors
Water collection, treatment and supply	E36	Other sectors

Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	E37-E39	Other sectors
Construction	F	Other sectors
Wholesale and retail trade and repair of motor vehicles and motorcycles	G45	Market services
Wholesale trade, except of motor vehicles and motorcycles	G46	Market services
Retail trade, except of motor vehicles and motorcycles	G47	Market services
Land transport and transport via pipelines	H49	Market services
Water transport	H50	Market services
Air transport	H51	Market services
Warehousing and support activities for transportation	H52	Market services
Postal and courier activities	H53	Market services
Accommodation and food service activities	I	Market services
Publishing activities	J58	Market services
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	J59_J60	Market services
Telecommunications	J61	Market services
Computer programming, consultancy and related activities; information service activities	J62_J63	Market services
Financial service activities, except insurance and pension funding	K64	Market services
Insurance, reinsurance and pension funding, except compulsory social security	K65	Market services
Activities auxiliary to financial services and insurance activities	K66	Market services
Real estate activities	L68	Non-market services
Legal and accounting activities; activities of head offices; management consultancy activities	M69_M70	Market services
Architectural and engineering activities; technical testing and analysis	M71	Market services
Scientific research and development	M72	Market services
Advertising and market research	M73	Market services
Other professional, scientific and technical activities; veterinary activities	M74_M75	Market services
Administrative and support service activities	N	Market services
Public administration and defence; compulsory social security	O84	Non-market services
Education	P85	Non-market services
Human health and social work activities	Q	Non-market services

Other service activities; Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; Activities of extraterritorial organizations and bodies	R_S, T, U	Market services

Table A3: Sectoral contribution to producer price inflation differential by country

	2001-2008		2009-2014	
	manufacturing and market services	non-market services and other sectors	manufacturing and market services	non-market services and other sectors
	Sectoral contribution to producer price inflation in Germany (percent)			
DEU	0.90	0.45	0.72	0.57
	Sectoral contribution to producer price inflation differential by country (percentage points)			
AUT	0.17	0.51	0.17	0.22
BEL	0.92	0.40	0.46	0.01
EST	2.13	2.41	0.71	0.40
FRA	0.20	0.71	-0.23	-0.04
GRC	0.97	1.34	-0.29	-0.96
ITA	0.80	0.79	0.09	-0.02
NLD	0.65	0.72	0.15	-0.20
PRT	0.31	1.32	-0.68	-0.14
SVN	2.34	1.79	-0.18	-0.22