# The Balassa-Samuelson effect in CEE economies: a CGE analysis

Jakub Boratyński[1], Jakub Borowski[2], Adam Czerniak[2], Dariusz Rosati[2]

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## 1. Introduction

The computable general equilibrium (CGE) framework allows to simulate the Balassa-Samuelson (BS) effect, by imposing productivity shocks at individual sector level. The CGE analysis of the BS effect is theoretical in principle, but features snapshot data on cost structures (technologies) of individual industries, distinguishing primary factor and intermediate input. The latter allows for a detailed accounting of price formation as compared with the common settings used in econometric models, with explicit link between prices of tradables and non-tradables through intermediate inputs. On the other hand, the CGE approach does not involve empirical verification of the phenomena under study, rather it relies on investigating consequences of alternative assumptions within sensitivity analysis.

Based on CGE model simulations of the Balassa-Samuelson effect for CEE economies, namely Czech Republic, Hungary and Poland, our study aims at:

- determining contributions of services' prices to changes in prices (unit costs) of tradable commodities, for a generic productivity shock;
- showing that the impact of productivity increase on real exchange rate appreciation largely depends on the price responsiveness of exports;
- determining potential magnitude of real appreciation caused by a composition of industry-specific productivity shocks, based on observed productivity trends; assessing competitiveness gains/losses by industries.

## 2. Model and data

Simulations are based on the ORANI-G model (Horridge 2003), extended with price decomposition formulations. The model was calibrated to 2014 data for the Czech Republic, Hungary and Poland, at 54-industry disaggregation level. Model databases were derived from WIOD 2016 edition (Timmer et al. 2015), using national Supply and Use Tables (SUT), as well as "symmetric" input-output tables (NIOT). Customization of WIOD data included: (1) estimation of tax and margin matrices for intermediate and final use, (2) split of commodity use, in the product-by-industry use table, into domestic and imported components, (3) split of value added into labor and capital cost, based on Eurostat data, (4) reclassification of re-exports as exports of domestic output.

For the most part, this study follows standard assumptions of the ORANI-G model (see Horridge 2003). One exception concerns export modeling, which combines downward-sloping foreign demand schedules

[1] University of Lodz
[2] Warsaw School of Economics

with the assumption of non-zero costs for producers of switching between supplies to domestic and foreign markets, based on CET formulation.

**3. Simulation setting**

In the simulations shocks are imposed on sectoral labor productivities, while the main results of interest are changes in relative prices: products versus services prices, and domestic versus foreign prices. The analysis is comparative static, and the simulation results are interpreted as persistent deviations from benchmark (in a hypothetical steady state situation). We take a long-run perspective, by assuming that capital stocks adjust to ensure required sectoral rates of return; labor supply is exogenous, and full employment is facilitated by adjustment of average wage. On the demand side, current account to GDP ratio is assumed fixed, investment is proportional to demand for fixed capital, and consumption adjusts to balance aggregate demand with supply (government consumption being proportional to household consumption).

We perform subsequently two sets of simulations, imposing:

1. 10% labor saving technical change, uniform across manufacturing industries;
2. differentiated labor productivity shocks for all industries, based on historical trends.

The Balassa-Samuelson effect arises as a result of relative productivity growth rates between countries. Ideally, one could use a global CGE model, imposing productivity shocks on both domestic and foreign economies. However, since we are using single country models, it was implicitly assumed that the world productivity levels and, hence, world prices, do not change. As a consequence, when the shocks are based on observed labor productivity changes, the results can in fact exaggerate real appreciation effect, as no productivity improvements are considered on the foreign part. From such a perspective, simulation outcomes may be viewed an upper bound of real appreciation effects within the adopted theoretical framework.

In interpreting the simulations, it is necessary to distinguish between labor saving technical change and labor productivity change. The former implies that the same output can be produced with less (say, 10% less) labor input. The latter, 'observed' labor productivity change, is a combination of pure labor saving technical change, and changes in the capital/labor (or in principle also changes in productivities of other factors of production, but those were not considered in the simulations). In simulations set 1, shocks were imposed directly as labor saving technical change, while in simulations set 2, 'observed' labor productivities were shocked, allowing the model to adjust pure labor efficiencies and capital/labor ratios accordingly. Labor productivity is interpreted as real value added per worker (including employees and the self-employed).

**4. Results: 10% labor saving technical change in manufacturing**

Effects of uniform labor saving technical change are considered for different sets of price elasticities of exports, equal to -20 and -5, respectively. Model formulation with downward-sloping foreign demand curves is a part of ORANI/MONASH tradition (Dixon, Koopman and Rimmer 2013), and it is also broadly consistent with evidence concerning Armington substitution elasticities. Dixon and Rimmer (2001, p. 222-225) demonstrate that export elasticities approximately equal to -4 can be derived for Australia from available estimates of Armington substitution elasticities, related to decisions on commodity supplies sourcing from different foreign directions. Finite values of export elasticities imply that domestic

producers have some market power in foreign markets, and so they have a certain influence on prices of commodities sold abroad, albeit limited – e.g. elasticity of -5 implies that 1% increase in price of exported commodity reduces foreign demand by 5%. In this line, elasticity value of -20 brings us very close to the more common representation of a small open economy, with fixed world prices and fully elastic demand. Nevertheless, given the large scale of shocks imposed simultaneously (particularly in the second set of simulations), we find this setting numerically more convenient than the one with strictly infinite elasticity of foreign demand. Unlike MCP representations of CGE models, our model does not allow the production or exports to shrink to zero, which would be the expected result in the simulation for a few exclusively export-oriented industries.

Our simulations suggest that even quite limited market power significantly reduces real appreciation effects (see table 1). Moving from the -20 to -5 elasticity case mitigates the estimated real appreciation by a factor of 3, from 1.19%-1.65% to 0.38%-0.53%, across the analyzed countries, as measured with the GNE deflator. This is effect can be interpreted as that a part of productivity gains are paid as a cost of export expansion.

Worth to note, the choice of deflator matters significantly for the assessment of the size of real appreciation. Assessments based on household consumption deflator are the highest, and the least sensitive to price elasticity of exports. On the other hand, the GDP deflator even indicates a slight depreciation for Czech Republic and Hungary, when the low export elasticity is considered (all price changes reported in table 1 should be interpreted relative to foreign prices expressed in domestic currency).

Price decompositions, presented in figures 1-3 (results aggregated to 9 sectors), show changes in unit cost of production broken down into the contributions of:

- direct labor saving in a given industry,
- changes in factor prices (wages and capital rentals),
- changes in prices of services used as intermediate inputs,
- changes in prices of other intermediate inputs (agriculture, mining and manufacturing products).

Decomposition is performed in two steps. First, regular simulation is performed, with labor saving technical change shocks. Among endogenous results from that simulation there are changes in: primary factor inputs per unit of gross output, factor prices, and prices of individual commodities. Second, these endogenous results are used as exogenous shocks in a simplified, accounting model (being an extract of equations from the full model), which calculates unit production costs by industries based on exogenous unit input requirements and input prices. All shocks are imposed simultaneously, while to determine their individual contributions to the changes in unit costs we use the Harrison, Horridge and Pearson (2000) method, available in GEMPACK software (Horridge et al. 2013).

Figures 1-3 illustrate how higher primary factor prices – mainly wages – resulting from manufacturing productivity boost translate to prices of non-manufacturing products and services. They also illustrate the role of services used as intermediate inputs in the price formation process. Given foreign trade exposure, prices of manufacturing products only fall insignificantly, compensated by the increase in wages and capital rentals (roughly 2/3 of the compensating effect), as well as intermediate input prices, mainly services (roughly 1/3 of the compensating effect). Prices of individual service types also contribute

significantly to the formation of prices of other service types, as well as agriculture, mining, and utilities prices.

Important to note, the existence of services used as intermediate inputs does not in any way change the nature of Balassa-Samuelson as such. However, their explicit treatment improves the accounting of how relative productivity changes might affect individual sectors' competitiveness, given that foreign trade is not facilitated in pure value added cost terms, but rather it includes (sector-specific) amounts of labor embodied in services. For example, a given manufacturing sector might heavily depend on imported intermediate inputs, whereas another sector might rely on services supplied domestically – in each case real appreciation would affect the manufacturers quite differently. With the current results we wish to put forward a view that detailed tracking of price formation is potentially an important issue for empirical studies, and to highlight the fact that such accounting is captured in the CGE framework.

**5. Results: labor productivity shocks based on 2004-2014 trends**

For the second set of simulations we used Eurostat data on real value added and employment by sectors to determine changes in labor productivity by industries in the years 2004-2014. The results were used as exogenous inputs to a scenario assuming that (1) the pattern of productivity changes in the analyzed economies is maintained in the next years, and (2) there are no changes in foreign prices. The latter assumption only reflects inability to analyze productivity changes taking place abroad in a single country setting, and – as discussed in section 3 – implies that the results should be treated an upper bound for actual possible outcomes (productivity improvements in the tradables sector abroad would mitigate real appreciation effect in the domestic economy). Still, the purpose of this study is not to formulate forecasts of real appreciation effects, but rather to examine general consequences of differentiated productivity changes, following sectoral patterns actually observed.

Macro results of the second simulation set are reported in table 2, and unit cost decompositions are illustrated in figures 4-6 (in this case reported at the full, 54 industry disaggregation level). Labor productivity changes in the years 2004-2014 were characterized by relatively large magnitudes and significant inter-sector differentials, including sign differences. In particular, certain service sectors exhibited labor using, rather than labor saving technical change. For Czech Republic only for 6 (out of 54) industries the cost saving due to improved labor productivity exceeds cost increase due to higher factor and intermediate input prices. Similarly, for Poland this is the case for only 8 industries, the remaining industries experiencing adverse impact on competitiveness, i.e. increase in average unit cost of production (note that even though export prices may rise only moderately, it is compensated by larger price increases of product varieties sold in the domestic market). Explanation of such an outcome can be probably linked to labor productivity deterioration in certain industries, particularly services. Another reason is the uneven distribution of productivity improvements among manufacturing sectors – in industries in which productivity improvement is moderate, the effects of higher factor prices overweight productivity gains. In the case of Hungary, the simulated real appreciation was much weaker than in the case of Czech Republic and Poland, partly due to significant productivity improvements taking place in the non-tradable sector. In this context, however, it should be mentioned that large variation of implied productivity changes across industries, as well as cases of significant year-to-year jumps, raise concerns about reliability of real value added data in some sectors.

## 6. Discussion

This paper demonstrates how a CGE model simulation can be used to decompose the Balassa-Samuelson effect, highlighting differentiated sectoral impacts of labor productivity improvements on unit production costs. We think it also calls for further study in the following areas:

- Reconciliation with empirical research: for example, Konopczak (2013) reports, based on econometric estimation results, that the BS effect causes annual inflation rate in Czech Republic to be approximately 2 p.p. higher versus the euro area; the respective differentials are approx. 1.5 p.p. for Hungary and 3 p.p. for Poland. These effects are higher than suggested by simulation results, although such a rough comparison is not fully adequate, due to various methodological issues, specifically different periods taken into account (1995-2010 in the cited work). We believe that reconciliation of results from CGE and econometric approaches could be beneficial in two ways. First, CGE formulation could be adapted to be more consistent with historical record. Second, CGE simulations could guide empirical research or support it with prior information (e.g. sensitivity analysis performed in this paper points to export elasticity as an interesting issue for econometric investigation).
- The role of exchange rate regimes: in the current study we assumed that economy-wide wage rate adjusts fully to clear the labor market after productivity changes – in this way the results are indifferent to exchange rate regime. However, with wage rigidities, changes in nominal exchange rate could facilitate adjustments of real wages in the economy, by modifying their purchasing power (as opposed to the fixed exchange rate case). Appropriate CGE simulation design, reflecting differences in real wage adjustments under alternative exchange rate regimes, is the case for further research.

## 7. References


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Table 1. Macro results: 10% labor saving technical change in manufacturing

| | Scenarios | | | | | |
|---|---|---|---|---|---|---|
| | Export elasticity = -20 | | | Export elasticity = -5 | | |
| | CZE | HUN | POL | CZE | HUN | POL |
| | *% changes* | | | | | |
| Real appreciation (GNE deflator) | 1.65 | 1.54 | 1.19 | 0.53 | 0.38 | 0.42 |
| Real appreciation (GDP deflator) | 1.37 | 1.35 | 1.04 | -0.24 | -0.28 | 0.05 |
| Real appreciation (Hhd consumption deflator) | 2.74 | 2.23 | 2.35 | 2.02 | 1.60 | 2.00 |
| Wage rate | 4.66 | 4.12 | 3.74 | 1.81 | 1.28 | 2.07 |
| Capital rental rate | 1.23 | 1.09 | 0.78 | 0.36 | 0.26 | 0.18 |
| Prices of household consumption | 1.43 | 1.38 | 0.98 | 0.41 | 0.29 | 0.27 |
| Prices of government consumption | 2.74 | 2.49 | 2.35 | 1.04 | 0.77 | 1.20 |
| Prices of investment | 1.23 | 1.09 | 0.78 | 0.36 | 0.26 | 0.18 |
| Prices of exports | -0.24 | -0.14 | -0.30 | -0.90 | -0.74 | -0.78 |
| Prices of imports | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GDP | 2.8 | 2.2 | 2.3 | 2.4 | 1.8 | 2.1 |
| Household consumption | 2.8 | 2.0 | 2.1 | 1.5 | 1.0 | 1.6 |
| Government consumption | 2.8 | 2.0 | 2.1 | 1.5 | 1.0 | 1.6 |
| Investment | 1.7 | 2.5 | 2.3 | 1.7 | 1.6 | 1.9 |
| Exports | 4.3 | 3.7 | 3.3 | 4.0 | 3.2 | 3.1 |
| Imports | 4.0 | 3.5 | 3.0 | 3.1 | 2.5 | 2.3 |

Figure 1. Decomposition of price changes, Czech Republic: 10% labor saving technical change in manufacturing (export elasticity = –20).

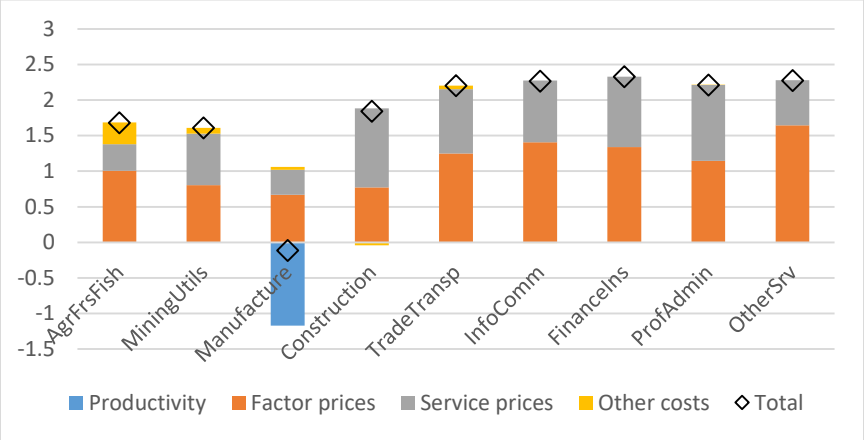


Figure 2. Decomposition of price changes, Hungary: 10% labor saving technical change in manufacturing (export elasticity = –20)

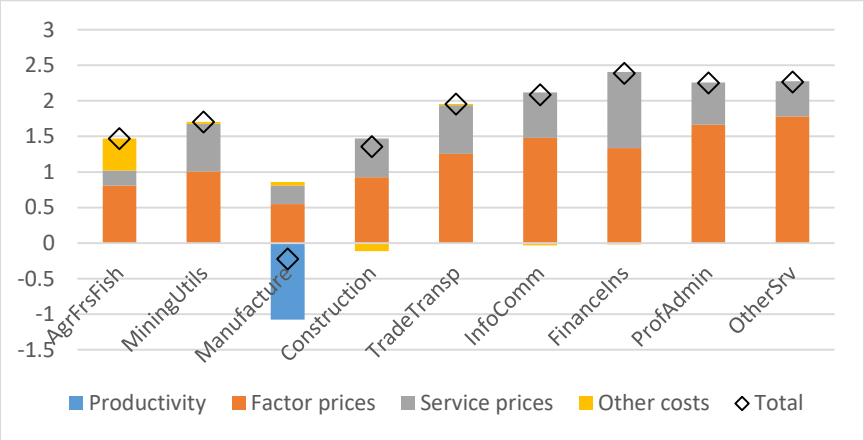


Figure 3. Decomposition of price changes, Poland: 10% labor saving technical change in manufacturing (export elasticity = –20)

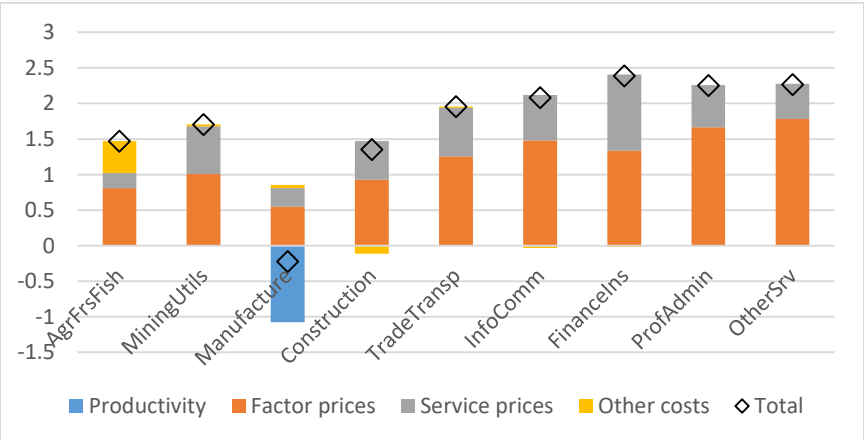

Table 2. Macro results: labor productivity shocks based on 2004-2014 trends

| | CZE | HUN | POL |
|---|---|---|---|
| | | *% changes* | |
| Real appreciation (GNE deflator) | 15.10 | 5.84 | 13.20 |
| Real appreciation (GDP deflator) | 13.87 | 5.37 | 12.58 |
| Real appreciation (Hhd consumption deflator) | 14.05 | 6.22 | 9.44 |
| | | | |
| Wage rate | 33.31 | 7.28 | 26.32 |
| Capital rental rate | 9.07 | 4.86 | 13.43 |
| | | | |
| Prices of household consumption | 14.16 | 5.52 | 10.66 |
| Prices of government consumption | 25.04 | 7.69 | 21.94 |
| Prices of investment | 9.07 | 4.86 | 13.43 |
| Prices of exports | -0.48 | -0.21 | -0.94 |
| Prices of imports | 0.00 | 0.00 | 0.00 |
| | | | |
| GDP | 12.5 | 4.1 | 10.9 |
| Household consumption | 13.7 | 2.1 | 10.6 |
| Government consumption | 13.7 | 2.1 | 10.6 |
| Investment | 4.6 | 9.2 | 9.3 |
| Exports | 34.1 | 19.6 | 28.6 |
| Imports | 33.8 | 19.9 | 27.4 |

Figure 4. Decomposition of price changes, Czech Republic: labor productivity shocks based on 2004-2014 trends

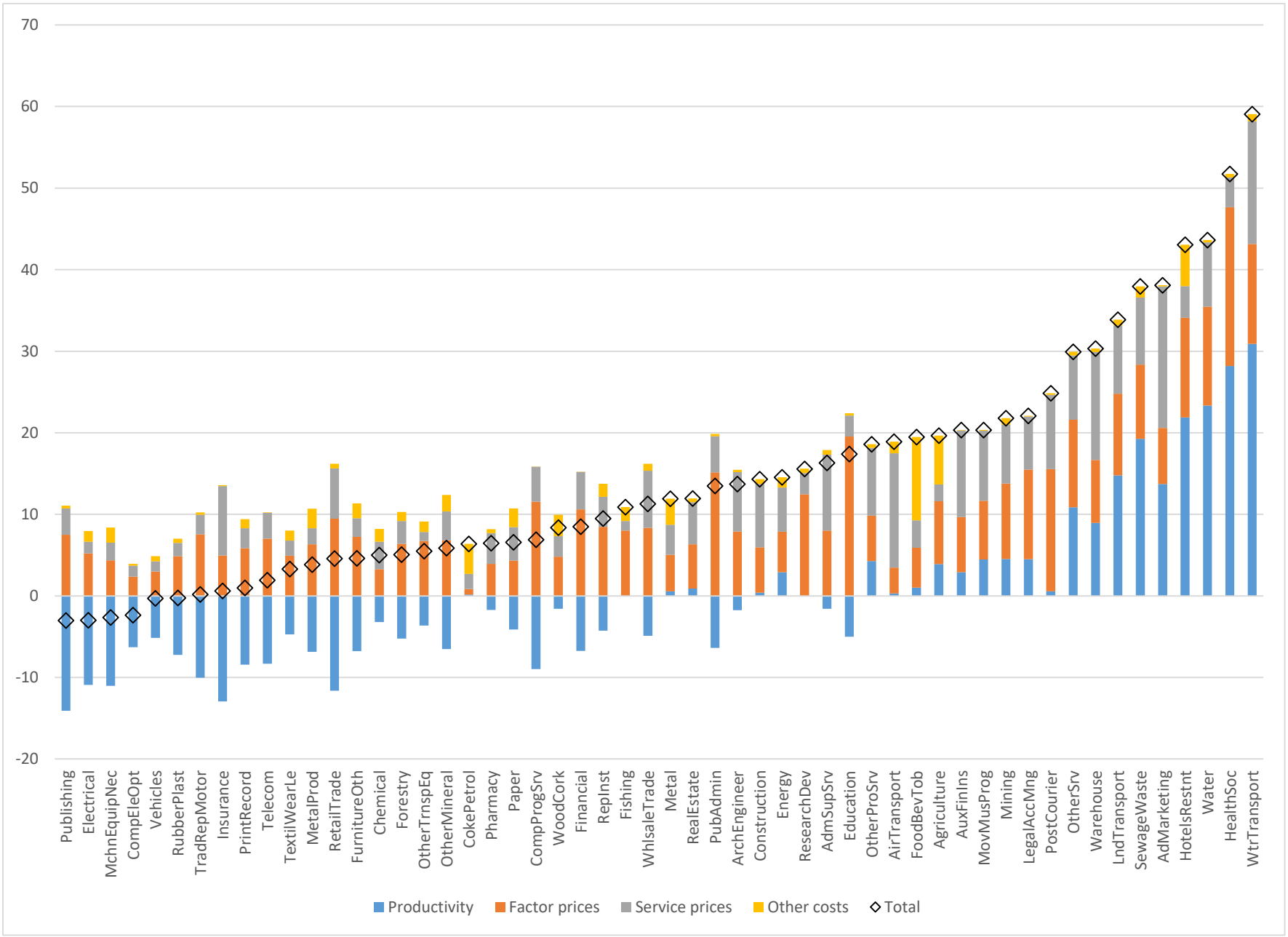

Figure 5. Decomposition of price changes, Hungary: labor productivity shocks based on 2004-2014 trends

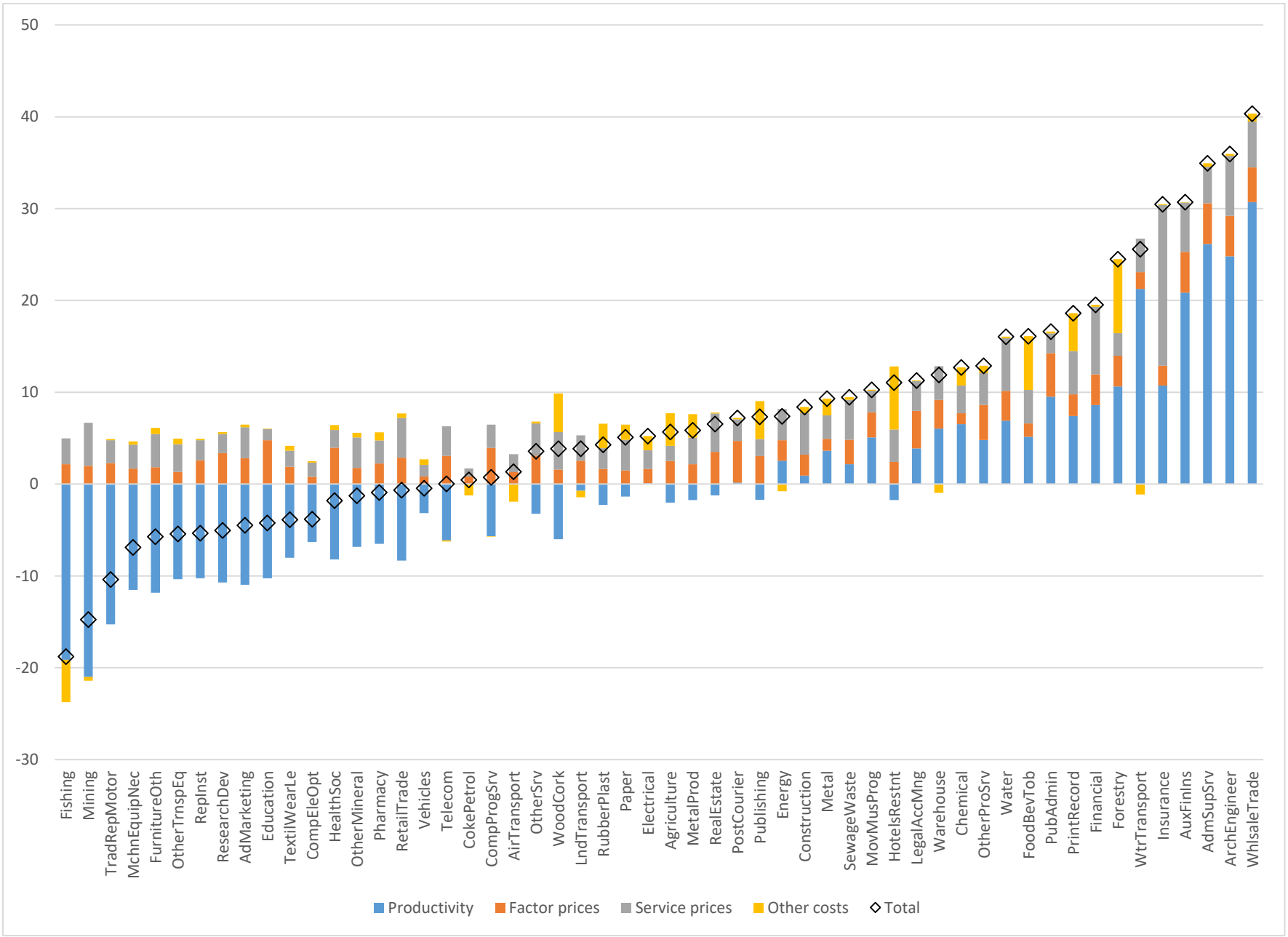

Figure 6. Decomposition of price changes, Poland: labor productivity shocks based on 2004-2014 trends

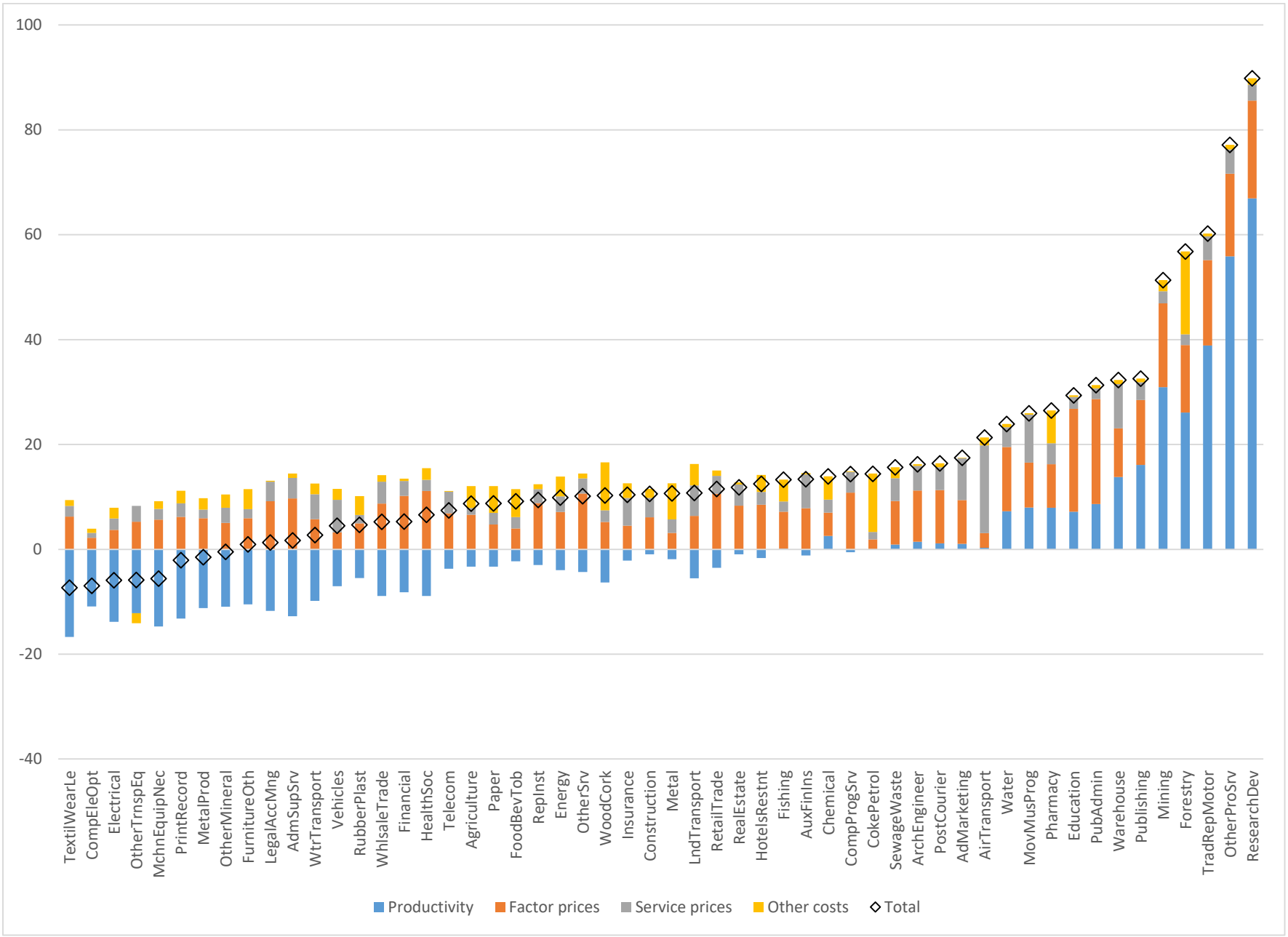

Table 3. Industry disaggregation details and symbols

| Short name | Aggregation | NACE code | Description |
|---|---|---|---|
| Agriculture | AgrFrsFish | A01 | Crop and animal production, hunting and related service activities |
| Forestry | AgrFrsFish | A02 | Forestry and logging |
| Fishing | AgrFrsFish | A03 | Fishing and aquaculture |
| Mining | MiningUtils | B | Mining and quarrying |
| FoodBevTob | Manufacture | C10-C12 | Manufacture of food products, beverages and tobacco products |
| TextilWearLe | Manufacture | C13-C15 | Manufacture of textiles, wearing apparel and leather products |
| WoodCork | Manufacture | C16 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials |
| Paper | Manufacture | C17 | Manufacture of paper and paper products |
| PrintRecord | Manufacture | C18 | Printing and reproduction of recorded media |
| CokePetrol | Manufacture | C19 | Manufacture of coke and refined petroleum products |
| Chemical | Manufacture | C20 | Manufacture of chemicals and chemical products |
| Pharmacy | Manufacture | C21 | Manufacture of basic pharmaceutical products and pharmaceutical preparations |
| RubberPlast | Manufacture | C22 | Manufacture of rubber and plastic products |
| OtherMineral | Manufacture | C23 | Manufacture of other non-metallic mineral products |
| Metal | Manufacture | C24 | Manufacture of basic metals |
| MetalProd | Manufacture | C25 | Manufacture of fabricated metal products, except machinery and equipment |
| CompEleOpt | Manufacture | C26 | Manufacture of computer, electronic and optical products |
| Electrical | Manufacture | C27 | Manufacture of electrical equipment |
| MchnEquipNec | Manufacture | C28 | Manufacture of machinery and equipment n.e.c. |
| Vehicles | Manufacture | C29 | Manufacture of motor vehicles, trailers and semi-trailers |
| OtherTrnspEq | Manufacture | C30 | Manufacture of other transport equipment |
| FurnitureOth | Manufacture | C31_C32 | Manufacture of furniture; other manufacturing |
| RepInst | Manufacture | C33 | Repair and installation of machinery and equipment |
| Energy | MiningUtils | D35 | Electricity, gas, steam and air conditioning supply |
| Water | MiningUtils | E36 | Water collection, treatment and supply |
| SewageWaste | MiningUtils | E37-E39 | Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services |
| Construction | Construction | F | Construction |
| TradRepMotor | TradeTransp | G45 | Wholesale and retail trade and repair of motor vehicles and motorcycles |
| WhlsaleTrade | TradeTransp | G46 | Wholesale trade, except of motor vehicles and motorcycles |
| RetailTrade | TradeTransp | G47 | Retail trade, except of motor vehicles and motorcycles |
| LndTransport | TradeTransp | H49 | Land transport and transport via pipelines |
| WtrTransport | TradeTransp | H50 | Water transport |
| AirTransport | TradeTransp | H51 | Air transport |
| Warehouse | TradeTransp | H52 | Warehousing and support activities for transportation |
| PostCourier | TradeTransp | H53 | Postal and courier activities |
| HotelsRestnt | TradeTransp | I | Accommodation and food service activities |
| Publishing | InfoComm | J58 | Publishing activities |

| Short name | Aggregation | NACE code | Description |
|---|---|---|---|
| MovMusProg | InfoComm | J59_J60 | Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities |
| Telecom | InfoComm | J61 | Telecommunications |
| CompProgSrv | InfoComm | J62_J63 | Computer programming, consultancy and related activities; information service activities |
| Financial | FinanceIns | K64 | Financial service activities, except insurance and pension funding |
| Insurance | FinanceIns | K65 | Insurance, reinsurance and pension funding, except compulsory social security |
| AuxFinIns | FinanceIns | K66 | Activities auxiliary to financial services and insurance activities |
| RealEstate | OtherSrv | L68 | Real estate activities |
| LegalAccMng | ProfAdmin | M69_M70 | Legal and accounting activities; activities of head offices; management consultancy activities |
| ArchEngineer | ProfAdmin | M71 | Architectural and engineering activities; technical testing and analysis |
| ResearchDev | ProfAdmin | M72 | Scientific research and development |
| AdMarketing | ProfAdmin | M73 | Advertising and market research |
| OtherProSrv | ProfAdmin | M74_M75 | Other professional, scientific and technical activities; veterinary activities |
| AdmSupSrv | ProfAdmin | N | Administrative and support service activities |
| PubAdmin | OtherSrv | O84 | Public administration and defence; compulsory social security |
| Education | OtherSrv | P85 | Education |
| HealthSoc | OtherSrv | Q | Human health and social work activities |
| OtherSrv | OtherSrv | R_S_T_U | 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 |